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ANNUAL HISTORICAL REPORT
CALENDAR YEAR 1990

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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13. ABSTRACT (Maximum 200 words)

This report contains information concerning the mission, organization, key staff, overall funding and significant research accomplishments of the US Army Research Institute of Environmental Medicine, a subordinate element of the US Army Medical Research and Development Command, for calendar year 1990. Also included are listings of published reports, abstracts, presentations and key briefings for each Research Division of the Institute and significant accomplishments and appointments of the professional staff.

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ANNUAL HISTORICAL REPORT -- AMEDD ACTIVITIES

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U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NATICK, MASSACHUSETTS 01760-5007

CALENDAR YEAR 1990

USARIEM
CY90

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GENERAL INFORMATION

ORGANIZATION

The United States Army Research Institute of Environmental Medicine (USARIEM) until 30 September 1990 was organized with an Office of the Commander, Scientific Technical Director, seven Research Divisions and a Research Support Division consisting of five functional Branches. Organization chart of USARIEM, dated 30 September 1990 is attached as Appendix A.

In accordance with Memorandum dated 25 September 1990, signed by the Deputy Commander of HQ, U.S. Army Medical Research and Development Command, provisional authority was granted the Commander, USARIEM, to execute the reorganization of the Institute. Organization chart of USARIEM, dated 1 October 1990 is attached as Appendix B. The effective date for the reorganization consolidates eight research Divisions into three Directorates:

a. The Occupational Health and Performance Directorate, Dr. James A. Vogel, Director. The Directorate incorporates the former Exercise Physiology Division, the Military Nutrition Division and the Health & Performance Division.

b. The Environmental Physiology and Medicine Directorate, Dr. Kent B. Pandolf, Director. The Directorate incorporates the former Military Ergonomics Division, the Altitude Research Division, and those components associated with the Cold Research Division and Heat Research Division human research mission areas.

c. The Environmental Pathophysiology Directorate, Dr. Roger W. Hubbard, Director. The Directorate incorporates the former Heat Research Division and the Experimental Pathology Branch, Cold Research Division.

Additional significant changes related to the reorganization include the following:

a. The establishment of the Research Plans and Operations Division, Dr. Murray P. Hamlet, Director. The components of the Division include: The Plans and Operations Branch, the Bioengineering Branch and the Animal Care Branch.

b. The former Research Support Division was redesignated as the Administrative Support Division, Marc L. Eisenmann, Captain, MS, Chief. The components of the Division include: the Resource Management Branch, the Information Management Branch and the Logistics Branch.

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LOCATION

USARIEM is located at the United States Army Natick Research, Development and Engineering Center (NRDEC), Natick, Massachusetts 01760-5007.

ACTIVATION AND ASSIGNMENT

a. By Section VI, General Order 33, Headquarters, Department of the Army, 20 September 1961, USARIEM was established as Class II activity under the jurisdiction of The Surgeon General, effective 1 July 1961.

b. General Order No. 40, Department of the Army, Office of the Surgeon General, 1 December 1961, assigned USARIEM to the United States Army Medical Research and Development Command, Washington, D.C., effective 1 July 1961.

c. The USARIEM was last provisionally reorganized by Memorandum dated 25 September 1990, signed by the Deputy Commander of HQ, U.S. Army Medical Research and Development Command, effective 1 October 1990.

TENANCY

a. USARIEM is a tenant on the NRDEC installation and receives administrative and logistical support from NRDEC on a reimbursable basis and in accordance with an annually renewed intra-Service support agreement.

b. The Pikes Peak Laboratory Facility, Colorado, is a subordinate activity of USARIEM and is utilized on a seasonal basis when a research requirement exists.

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MISSION

To sustain and maximize the health and performance of individual military personnel, crews and troop populations through the conduct of basic and applied research programs in environmental medicine (heat, cold and altitude), and military work performance, training and nutrition. The Institute conducts basic research to elucidate mechanisms and sequelae of environmental stress and injury, and performs applied research to provide preventative and therapeutic countermeasures to the performance decrements, injuries and illnesses associated with military operations which expose forces to a wide spectrum of environmental conditions, physical and mental demands, materiel systems hazards and combat stress. Defines the complex interaction of environmental stress, operational stress and Army systems. Develops, evaluates and assists in the implementation of strategies to protect the soldier and enhance performance. In coordination with the U.S. Army Natick Research, Development and Engineering Center and through liaison with other Federal agencies, conducts research to develop the technology base required to evaluate feeding strategies for operational rations and nutritional supplements to minimize soldier performance decrements under sustained combat conditions. Discharges the Army Surgeon General's responsibilities as DOD executive agent for nutrition. Assists USANRDEC in the development of personal clothing and equipment by assessing the physiological impact of these items under all climatic conditions. Provides technical advice and consultant services to Army commanders, installations and activities in support of the Army Preventive Medicine Program and, on request, to other Federal agencies.

USARIEM
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PERSONNEL

STRENGTH AS OF: 31 December 1990

CIVILIANS	AUTHORIZED	ACTUAL
SES	1	1
GM	7	7
GS	88	78
WG	2	2
TPT	2	6

OFFICERS	AUTHORIZED	ACTUAL
MC	5	8
MS	12	12
VC	3	2
SP	2	3

ENLISTED	AUTHORIZED	ACTUAL
	54	50

TOTAL:	AUTHORIZED	ACTUAL
	176	169

USARIEM
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KEY STAFF AS OF: 31 DECEMBER 1990

Gerald P. Krueger, COL, MS, Ph.D., Commander and Scientific/ Technical Director

John F. Glenn, LTC, MS, Ph.D., Deputy Commander

Marc L. Eisenmann, CPT, MS, M.B.A., Executive Officer and Director, Administrative Support Division

Stephen Grady, Jr., SSG, Chief Medical NCO

James A. Vogel. Ph.D., Director, Occupational Health & Performance Directorate

John F. Patton, Ph.D., Chief, Occupational Physiology Division, Occupational Health & Performance Directorate

Bruce H. Jones, LTC, MC, M.D., Chief, Occupational Medicine Division, Occupational Health & Performance Directorate

Eldon W. Askew, COL, MS, Ph.D., Chief, Military Nutrition Division, Occupational Health & Performance Directorate

Mary Z. Mays, MAJ, MS, Ph.D., Chief, Military Performance & Neuroscience Division, Occupational Health & Performance Directorate

Kent B. Pandolf, Ph.D., Director, Environmental Physiology & Medicine Directorate

Michael N. Sawka, Ph.D., Chief, Thermal Physiology & Medicine Division, Environmental Physiology & Medicine Directorate

Richard R. Gonzalez, Ph.D., Chief, Biophysics & Biomedical Modeling Division, Environmental Physiology & Medicine Directorate

Allen Cymerman, Ph.D., Chief, Altitude Physiology & Medicine Division, Environmental Physiology & Medicine Directorate

Roger W. Hubbard, Ph.D., Director, Environmental Pathophysiology Directorate

Wilbert D. Bowers, Ph.D., Chief, Cellular Physiology & Pathology Division, Environmental Pathophysiology Directorate

Ralph P. Francesconi, Ph.D., Chief, Comparative Physiology Division, Environmental Pathophysiology Directorate

KEY STAFF (continued)

Murray P. Hamlet, D.V.M., Director, Research Programs & Operations Division

Andre A. Darrigrand, MAJ, VC, D.V.M., Chief, Animal Care Branch, Research Programs & Operations Division

John M. Foster, Chief, Bioengineering Branch, Research Programs & Operations Division

ADMINISTRATIVE SUPPORT DIVISION:

Monica O'Guinn, 1LT, MS, Adjutant/Detachment Commander
Tim J. Jardine, CPT, MS, Chief, Logistics Branch
Marie E. Stephens, Personnel/Manpower, Resource Management Branch
Violet M. Trainer, Program and Budget, Resource Management Branch
Anthony J. Guerra, Chief, Information Management Branch

USARIEM
FY90

ALLOCATION AND FUNDING

DA PROJECT NO. AND TITLE		FUNDS
3M161101A91C	- In-House Laboratory Independent Research	$ 58,000
3M161102BS15	- Science Base of System Health Hazard Research	1,540,000
3M162787A875	- Medical Chemical Defense - Exploratory Development	195,000
3M162787A878	- Health Hazards of Military Materiel	417,000
3M162787A879	- Medical Factors Enhancing Soldier Effectiveness	3,298,000
3M263002D819	- Field Medical Protection and Human Performance Enhancement - Nonsystems Advanced Development	100,000
3M263002D995	- Medical Chemical Defense Life Support Materiel - Nonsystems Advanced Development	453,000
3M463807D836	- Combat Casualty Care Materiel - Advanced Development	30,000
3M463807D993	- Medical Defense Against Chemical Threats - Advanced Development	313,000
Total FY90 Program		$6,404,000

SUPPLY AND MAINTENANCE ACTIVITIES

During CY90, 3140 requests were processed by the Logistics Branch as indicated below:

Non-Expendable	278
Durable	263
Expendable	2599

Additionally, the Logistics Branch turned in 439 items of excess equipment, processed 2 reports of survey, and submitted 109 work orders and 555 maintenance service orders to Facilities Engineering.

The Medical Maintenance Section performed preventive maintenance on 1399 items and sent 402 items to calibration.

BUILDING AND FACILITY EQUIPMENT

INSTRUMENTATION DESIGN AND DEVELOPMENT

The Bioengineering Branch contributed to the design and development of the following items for the period CY90:

a. Armcrank Ergometer Tachometer. (Completed)

b. Tissue Cooling Device for electron microscopy studies of tissue frostbite. (Completed)

c. Animal Water Feeders. (Completed)

d. Weaponeer Automation Device for computer control of Weaponeer target selection, target presentation intervals,and reaction time measurements. (One of two units completed)

e. Oxygen Delivery System for Altitude Chamber. (Completed)

f. Moving Laser Target Tracking Device for performance testing using the M-16 rifle. (Initiated)

g. Tissue Cooling/Rewarming Device for studying hypothermia of endothelial cells. (Completed first prototype)

h. Pacing Device for Load Carriage Analysis. (Completed)

i. Overhead Trolley Cabling Support System (Completed)

j. Feasibility Study of Group Lifting Device. (Initiated)

k. Support Stanchions for Treadmill Litter Carry Study on two treadmills. (Completed)

l. Remote Treadmill Speed Controller. (Completed)

m. Treadmill Tachometer for Climatic Chambers.(Completed)

n. VCR/Monitor Transport System. (Completed)

o. Visual Alarm System for Altitude Chamber. (Completed)

p. Rat Intubation Restraint. (Completed)

q. Biomechanics Force Platform Modifications to include Accelerometer/EEG integration package. (Completed)

r. Uranyl Acetate Work Area Enclosure. (Completed)

s. Treadmill Safety Device for protection of human volunteers while exercising on treadmills. (Two of four completed)

t. Textile Water Vapor Resistance Measuring Apparatus. (Completed)

BUILDING MODIFICATIONS

a. Asbestos removed from mechanical equipment rooms 025 and 144.

b. Contract awarded to remove asbestos from the penthouse equipment room, second floor, and basement hallways.

c. Architectural study completed that outlines $1.2 million project to totally upgrade heating, ventilation, air conditioning, and plumbing system. Study is basis for awarding a contract to design the upgraded HVAC system.

d. Contract awarded to install two new environmental chambers for the chamber 236 complex.

e. Hypobaric chamber control system upgraded with microprocessor controls.

f. Power transformer retrofilled with non-PCB containing oil.

g. Conduit for computer cables laid between ARIEM and and its offices in the Health Clinic building.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. There is little information regarding the direct and indirect effects of lowered blood O_2 tensions on skeletal muscle strength. However, there are a number of time dependent altitude-induced physiological changes which can affect muscular strength. These changes include an uncompensated respiratory alkalosis, an increase in adrenergic activity, and a reduction in lean body mass. During the first few days of altitude exposure, individuals become alkalotic, and sympathetic nervous activity is significantly increased. Both of these changes have been associated with improvements in muscular strength. We measured hand grip strength in 35 male soldiers at Ft. Riley, KS (450 m), and again after 2-3 days residence at the Santa Lucia base camp near Potosi, Bolivia (3500-4050 m). Strength was assessed, in seated subjects, using an isometric strain gauge dynamometer. With the subject voluntarily exerting a maximal contraction, peak force in kgs was recorded. Each subject performed three maximal contractions separated by a least one minute of rest, with the highest value being used for analysis. The mean (±SD) grip strength measured at low altitude and after exposure to moderate altitude was 52.2±7.62 kg and 54.2 ±6.76 kg, respectively. There was no significant difference in hand grip strength measured after 2-3 days exposure to moderate altitude as compared to baseline.

2. Loss of body weight is often a consequence for sea-level natives chronically exposed to altitude. The amount and rate of weight loss is affected by a number of factors, including altitude-induced suppression in appetite, physical exertion, diuresis, and non-availability of adequate amounts of food or water. Body weight and body composition changes were estimated in a group of 20 male soldiers after three weeks' residence at high altitude (3500-4050 m), during a field training exercise. The soldiers were measured during baseline testing at Ft. Riley, KS and again at the end of 3 weeks of residence at the base camp near Potosi, Bolivia. The sea-level baseline mean (±SD) for age, height, weight, and abdominal circumference of the group was 24.8±5.1 years, 173.99±7.54 cm, 75.15±10.79 kg and 84.58 ±7.38 cm, respectively. Fat-free mass, fat mass and percent body fat were calculated from the equation by Wilmore and Behnke (J. Appl. Physiol. 27:25,1969). The baseline mean (±SD) fat free mass, fat mass, and %fat were 63.37±8.17 kg, 11.78±4.81 kg and 15.31± 5.42 percent. After three weeks'

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residence at high altitude, the means (±SD) for weight, fat free mass, fat mass and % body fat were 72.17±10.19 kg, 61.95±7.60 kg, 10.23±4.67 kg and 13.80±5.35 percent, respectively. After three weeks of residence at high altitude, the mean weight loss for the group was 2.98 kg. The composition of the mean body weight loss was estimated to be 47% fat-free mass and 53% fat mass.

3. A prototype computerized device was developed by the Altitude Physiology and Medicine Division to quantitate upper extremity motor performance. The results of the first chamber study utilizing this device demonstrated that subclinical alterations in upper extremity speed are associated with mild, reversible acute mountain sickness (AMS) and provided evidence that hypoxia may produce supraspinal inhibition of motor pathways. This study also raised some questions concerning the possibility that a cognitive component may have influenced the subjects' strategy in performing the task. Therefore, in a subsequent study with modified subject instructions and target size an effort was made to eliminate the possible influence of the cognitive component. Another objective of this study was to determine whether breathing supplemental oxygen during the task would alter the results. Preliminary results of this study agree with the results of the previous study, suggesting that only speed-related parameters decrease at high altitude with no significant changes in the error indices of subjects afflicted with AMS. The administration of supplemental oxygen did not appear to significantly alleviate the decrement in motor performance. These data provide evidence that alterations in motor function during simulated altitude exposure may be the result of subclinical diffuse brain swelling and not hypoxemia *per se*.

4. The commonly-held belief that intracellular fluid volume (ICF) increases but total body water (TBW) does not change at altitude was not supported by recent studies where body fluid distribution was determined in nine adult males before and after 10 days of altitude exposure (4300 m). TBW was measured by $H_2{}^{18}O$ dilution, apparent extracellular fluid volume (ECF_a) was estimated from the sodium bromide dilution space corrected for tracer distribution outside of the ECF. The percent change in plasma volume (PV) was estimated from changes in hemoglobin concentration and hematocrit. Apparent intracellular fluid volume was calculated (ICF_a = TBW -

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ECF_a). Ten days at high altitude resulted in significant decreases (±SE) in body mass (86.6±4.6 to 82.2±4.3 kg), TBW (47.6±2.2 to 45.9±1.9 l), ICF_a (19.3±1.4 to 16.3±1.3 l), and PV (-20.0±1.4 %). The ECF_a did not change significantly (28.2±1.0 to 29.6±1.6 l). The decrease in TBW accounted for about 40% of the loss of body mass. These data suggest that prolonged hypoxia in man results in both cellular hypohydration and decreased TBW.

5. The energy balance and water intakes of 7 male soldiers were measured during a physically demanding, 6-day field exercise at 2100 to 3100 m elevation. Air temperature and wind speed ranged from -15 to +5°C, and from 0 to 20 $m \cdot s^{-1}$, respectively. Energy expenditure was estimated by both doubly labeled water ($^2H_2{}^{18}O$) and from the change in body energy stores and food intake (intake balance energy expenditure). Water intake was measured by both the two-point ^2H_2O elimination method and by daily logbook records of water consumed from clear graduated canteens. Body energy store changes were calculated from hydrostatic weighing and anthropometric measurements made before and after the field exercise. Doubly labeled water energy expenditure (mean±SE) (4248±577 kcal/d) did not differ from intake balance energy expenditure estimated from food intake and either hydrostatic weighing (4233±1468 kcal/d) or anthropometric (4623±387 kcal/d) measurements. Water intake by the ^2H_2O elimination method measured 101±21% (N=5) or 3111±473 g water/d compared to a recorded water intake of 3020±385 ml/d. In conclusion, the energy expenditure estimate by the DLW method and the water intake estimate by the ^2H_2O elimination method were valid under adverse altitude/cold field conditions.

6. Acute mountain sickness (AMS) is a symptom complex which includes headache, nausea, dizziness, and insomnia. Symptoms usually become noticeable after 4-8 h of exposure to altitudes greater than 3000 meters, reach their peak severity within the first 24 to 48 hours and then gradually recede over the ensuing week. The purpose of this study was to determine if exercise would alter the onset, incidence, and severity of the symptoms of AMS. Ten male subjects (means: 19.7 yr, 77.0 kg, and 176.3 cm) lived in a hypobaric chamber at sea level (50 m) or under simulated altitude conditions (4600m, 428 torr), with half the subjects exercising and

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

half remaining sedentary. Subjects walked/ran on treadmills or cycled on a bicycle ergometer at 50 to 75% of their predetermined maximal oxygen consumption ($\dot{V}O_2$ max) in exercise/rest cycles of 20 min/10 min. AMS symptomatology was assessed using the Environmental Symptoms Questionnaire. Exercise did not increase symptomatology at sea level. At altitude AMS symptomatology was significantly increased relative to sea level in both sedentary and exercising subjects. There was no significant difference in symptomatology between the sedentary and exercise periods at altitude. When subjects were divided into low fit (n=6, mean $\dot{V}O_2$ max = 39.3 ml/kg) and high fit (n=4, mean $\dot{V}O_2$ max=46.3 ml/kg) groups, symptomatology of the fit group either improved or did not worsen with exercise whereas the symptomatology of the unfit group was exacerbated. This study showed: 1) the symptoms of AMS will occur independently of the activity level of an individual, and 2) increased activity at altitude hastens the onset and increases the incidence and severity of AMS in unfit individuals.

7. Individuals exhibit different sensitivities to acute mountain sickness (AMS) with some individuals showing little or no symptoms of AMS and others severely incapacitated. The objective of this study was to determine if it is possible to predict individual susceptibilities to AMS based on ventilatory responses to hypoxia (HVR) and hypercapnia (HCVR) performed prior to deployment to high altitude. HVR and HCVR tests were performed on 47 males (25.2 yr, 77.7 kg, 176.3 cm) at FT Riley, KS (450 m) prior to deployment to Potosi, Bolivia (3500-4050 m). AMS symptomatology was assessed using the Environmental Symptoms Questionnaire during the first three days at altitude. Thirty-eight percent were determined to have AMS during the first three days of deployment. The HVR and HCVR tests were not able to predict who did or did not develop AMS ($r<0.17$). Sea-level values for subsequent symptomatic vs. nonsymptomatic soldiers for resting ventilation (13.0 vs 12.9 $l \cdot min^{-1}$), end-tidal PCO_2 (37.0 vs 38.2 torr), HVR (1.09 vs 1.01 change in ventilation/change in oxygen saturation), or HCVR (2.20 vs 2.07 change in ventilation/change in end-tidal PCO2) were not significantly different.

8. Since a significant proportion of the US Army population smoke cigarettes which may compromise oxygen transport, the hypothesis

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was tested that cigarette smoking would increase AMS symptomatology in 47 soldiers to be deployed to Potosi, Bolivia (3500-4050 m). Soldiers were divided into SMOKERS (n=25, >0.5 pack/day) and NONSMOKERS (n=22, never smoked) with no differences found between groups in age, weight, height. No differences were found in mean values for minute ventilation (SMOKERS: 12.0 vs NONSMOKERS: 13.9 l/min), end-tidal CO_2 (37.8 vs 37.6 torr), HVR (1.08 vs 1.00 change in ventilation/change in saturation), or HCVR (2.02 vs 2.24 change in ventilation/change in end-tidal CO2). Results from the Environmental Symptoms Questionnaire indicated that there was no difference in the proportion of those who had AMS; 40% of the SMOKERS (10 of 25) and 36% of the NONSMOKERS (8 out of 22). The use of hypoxic and hypercapnic ventilatory tests also could not predict development AMS, based on smoking history.

9. Hydrostatic weighing is considered a "gold standard" for estimation of body composition, but there are a number of potential sources of error associated with this method that can affect the procedures accuracy. These include motivation, fear of water, and residual volume errors. To overcome these problems, the dual-energy absorptiometry technique (DEXA) was tested against hydrostatic weighing (HW) using seven members of the investigative team (7 males, means: 38.1 yr, 80.0 kg, and 175.1 cm), before and after spending 23 days on a field study in Potosi, Bolivia (3500-4050 m). DEXA measurements were obtained with a total body scanner (DPX, Lunar Radiation Corp.,WI) making a series of transverse scans from head to toe of the subject at 1-cm intervals. Data were collected showing a mean decrease in body weight of 1.4 kg during the exposure (range: -4.8 kg to +1.0 kg). DEXA provided results for percent fat which did not differ from the HW results either before (21.0% vs 21.7%) or after (20.1% vs 21.1%) the exposure. The DEXA method was found to be as accurate as the established HW method and may be the method of choice since it requires little subject involvement, is not uncomfortable, and can be performed in 15 minutes or less.

10. The loss of body weight is common when sea-level residents temporarily reside at high altitude. Due to the difficulty in accurately determining composition of the weight loss while at altitude, less accurate, indirect methods such as skinfolds have

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been used. The purpose of this study was to determine the validity of using bioelectrical impedance to assess the body composition changes associated with altitude-induced weight loss and compare results to the standard hydrostatic weighing method (HW). Sixteen males (means: 27.7 yr, 87.7 kg, 179.4 cm) had their percent body fat (%fat), fat-free weight (FFW), and fat weight (FW) determined by HW and bioelectrical impedance (BIA) before and after a 16-day sojourn at altitudes of 3700-4300 m. BIA was also used on days 2,4,11,12,and 16 at altitude. HW and BIA values before exposure, were nearly identical for %fat (HW: 16.6% vs BIA: 16.3%), FFW (70.3 kg vs 70.4 kg), and FW (14.4 kg vs 14.4 kg). With a mean decrease of 5.9 kg after the exposure, results diverged: %fat (13.6% vs 16.2%, $p<0.01$), FFW (67.9 kg vs 65.7 kg, $p<0.01$), and FW (11.0 kg vs 13.1 kg, $p<0.01$). With this disparity, it is concluded that the BIA for estimation of body composition changes at altitude should be avoided.

11. Submarine crews live in atmospheres containing variable levels of oxygen (O_2) and carbon dioxide (CO_2). Under these conditions significant reduction of O_2 may impair mental function during physical exertion. Psychomotor performance was measured in 12 exercising men during the 26th and 57th hours of exposure to 21, 17, and 13% O_2 in a hypobaric chamber. After 26 h, subjects exercised at 35 and 65% of predicted $\dot{V}O_2$ max. The psychomotor test scores (timed arithmetic) were significantly decreased by the 13% exposure condition but not by 17% O_2 or the work rate. After 57 h, subjects repeated the arithmetic task at rest and at 65% of predicted $\dot{V}O_2$ max. Reductions in math scores were found to result from work rate but not from the exposure condition. It was concluded that levels of oxygen between 21 and 17% O_2 do not compromise mental function.

12. The health effects of 63-hour exposures to flame-retardant atmospheres were studied by exposing twelve men to 17 and 13% oxygen (0.9% CO_2) at normobaric pressures. Compared to 21% O_2, 17% O_2 diminished the flame size of ignited wicks and slowed the melting rates of candles. Thirteen percent O_2 prevented the flaming combustion of cellulosic materials. Subjects' responses to the Environmental Symptoms Questionnaire indicated that 17% O_2 did not cause significant symptoms of acute mountain sickness; but 13% O_2

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

caused significant symptoms in 5 of 12 men. It was concluded that men can live comfortably in a normobaric, flame-retardant atmosphere consisting of 17% O_2 and 0.9% CO_2.

13. Fourteen individuals experienced High Altitude Pulmonary Edema (HAPE) from a group of 364 soldiers and marines who arrived at high altitude in Potosi, Bolivia during the period 24 June - 28 July 1990. Three had to be evacuated back to the United States when symptoms could not be resolved locally. Two of the HAPE patients had taken acetazolamide as a prophylaxis for acute mountain sickness. All of the 55 marines participating in the Bolivian exercise received prophylactic acetazolamide and none reported serious altitude related symptoms. Treatment of HAPE varied per individual and included the use of oxygen, diuretics, acetazolamide, positive pressure ventilation, and a portable hyperbaric bag (Gamow Bag). The Gamow Bag was used to treat five patients. Four of the five patients treated in the Bag exhibited complete resolution of symptoms within 20 minutes of initial hyperbaric exposure. Two of the four patients initially responding to hyperbaric therapy subsequently relapsed into HAPE and required evacuation.

14. The potential interference of a gas currently used to measure ventilation-perfusion ratio in animal and human lungs was studies to determine if it alters the capability of three different instruments to measure PO_2 or O_2 content. Blood was tonometered oxygen at three oxygen concentrations (10, 16 and 21%) with and without an experimental gas mixture consisting of ethane, cyclopropane, and sulfur hexafluoride with three instruments (ABL300, Co-Oximeter, and Lex-02-Con). The results were compared with O_2 saturations derived from the Siggard-Anderson equation. The experimental gas had no affect on PO_2 values measured by the COOX and ABL methods, but did affect the LEX measurements by a mean of 5 percent. The ABL results more closely approximated the known saturation values. Replacement of the inert gas with nitrogen (to account for the dilution effect) did not affect the COOX or ABL at all oxygen concentrations. However, nitrogen dilution did account for 50% of the LEX error, resulting in a mean difference in O_2 saturation of 2.5 % due to inert gas. The precision of the COOX and ABL were good to excellent at 16% and 21% and fair to good at

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

the lowest O_2 level. The LEX had the worst precision of all instruments tested at all oxygen concentrations with and without inert gas.

PUBLICATIONS:

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3. Huang, S.Y., P.R. Bender, B.M. Groves, R.E. McCullough, R.G. McCullough, A.J. Micco, M. Manco-Johnson, A.J. Hamilton, P.D. Wagner, A. Cymerman and J.T. Reeves. Cerebral blood flow during exercise at sea level and high altitude. In: Hypoxia: The Adaptations. J.R. Sutton, G. Coates, and J.E. Remmers (Eds.). BC Decker, Toronto, 1990, pp.196-199.

4. Huang, S.Y., K.W. Tawney, P.R. Bender, B.M. Groves, R.E. McCullough, R.G. McCullough, A.J. Micco, M. Manco-Johnson, A. Cymerman, E.R. Greene and J.T. Reeves. Internal carotid flow velocity with exercise before and after acclimatization to 4300 m. J. Appl. Physiol. 1-18, 1990.

5. Knight, D.R., A. Cymerman, J.A. Devine, R.L. Burse, C.S. Fulco, P.B. Rock, D.V. Tappan, A.A. Messier and H. Carhart. Symptomology during hypoxic exposure to flame retardant chamber atmospheres. Undersea Biomedical Res. 17(1):33-44, 1990.

6. Knight, D.R., C.L. Schlicting, C.S. Fulco and A. Cymerman. Mental performance during submaximal exercise in 13 and 17% oxygen. Undersea Biomedical Res. 17(3):223-230, 1990.

ALTITUDE RESEARCH DIVISION

PUBLICATIONS:

7. Kolka, M.A., L.A. Stephenson, A.E. Allan and P.B. Rock. Atropine-induced cutaneous vasodilation decreases esophageal temperature during exercise. Am.J. Physiol. 257:R1089-1095, 1990.

8. Malconian, M.K., P.B. Rock, H. Hultgren, H. Donner, A. Cymerman, B. Groves, J. Reeves, J. Sutton, M. Nitta and C.S. Houston. The electrocardiogram at rest and exercise during a simulated ascent of Mt. Everest (OEII). Am.J. Cardiol. 65:1475-1480, 1990.

9. Malconian, M.K., H. Hultgren, M. Nitta, J. Anholm, C.S. Houston and H. Fails. The sleep electrocardiogram at extreme altitudes (OEII). Am. J. Cardiol. 65:1014-1020, 1990.

10. Meehan, R.T., G.R. Taylor, P.B. Rock, T.H. Mader, N. Hunter and A. Cymerman. An automated method of quantitating retinal vascular responses during exposure to novel environmental conditions. Ophthalmology 97(7):875-881, 1990.

11. Reeves, J.T., B.M. Groves, A. Cymerman, J.R. Sutton, P.D. Wagner, D. Turkevich and C.S. Houston. Operation Everest II: Cardiac filling pressures during cycle exercise at sea level. Respir. Physiol. 80:147-154, 1990.

12. Reeves, J.T., B.M. Groves, P.D. Wagner, A. Cymerman, P.M. Young, P.B. Rock, M.K. Malconian, J.R. Sutton, H. Green and C.S. Houston. Operation Everest II: Maintained muscle energy stores during exercise at extreme altitude. In: High-Altitude Medical Science. G. Ueda (Ed.). Matsumoto, Japan, 1990, pp. 3-12.

13. Schoene, R B., R.C. Roach, P.H. Hackett, J.R. Sutton, A. Cymerman and C.S. Houston. Operation Everest II: Ventilatory adaptation during gradual decompression to extreme altitude. Med Sci. Sports Exerc. 22(6):804-810, 1990.

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ALTITUDE RESEARCH DIVISION

PUBLICATIONS:

14. Sun, S.F., S.Y. Huang, J.G. Zhang, T.S. Droma, G. Banden, R.E. McCullough, A. Cymerman, J.T. Reeves and L.G. Moore. Decreased ventilation and hypoxic ventilatory responsiveness are not reversed by naloxone in Lhasa residents with chronic mountain sickness. Am. Rev. Respir. Dis. 142(6):1294-1300, 1990.

ABSTRACTS:

15. Askew, E.W., M.S. Rose, G.M. Hashiro, P.B. Rock and C.S. Fulco. Carnitine excretion following exhaustive exercise at sea level and high altitude: Influence of caffeine. FASEB J. 4:A801, 1990.

16. Baker, C.J., R.W. Hoyt, T.E. Jones, C.S. Fulco and A. Cymerman. Dietary considerations of a carbohydrate supplement at high altitude. FASEB J. 4:A567, 1990.

17. Burse, R.L., P.B. Rock, A.J. Hamilton, C.S. Fulco and A. Cymerman. The cold pressor test as a predictor of acute mountain sickness (AMS): Further results. FASEB J. 4:A414, 1990.

18. Fulco, C.S., R.W. Hoyt, C.J. Baker, J. Gonzalez and A. Cymerman. Use of bioelectrical impedance and anthropometry to assess body composition changes at high altitude. FASEB J. 4:A567, 1990.

19. Hoyt, R.W., C.S. Fulco, T.P. Stein, R.R. Wolfe, M.J. Durkot and A. Cymerman. Effect of high altitude residence on lipolysis and glucose production during prolonged exercise. FASEB J. 4:A567, 1990.

20. Kamimori, G.H., S.A. McCoy, C.S. Fulco, A. Cymerman and R.W. Hoyt. The effects of chronic altitude on caffeine pharmacokinetics and hepatic blood flow in humans. Med. Sci. Sports Exerc. 22:S90, 1990.

21. Lieberman, H.R., E.W. Askew, R.W. Hoyt and B. Schukitt-Hale. Decreased availability of the neurotransmitter precursor tryptophan may account for decrements in mental performance associated with undernutrition. FASEB J. 4:A674, 1990.

ALTITUDE RESEARCH DIVISION

ABSTRACTS:

22. Sun, S.F., C.W. Pickett, R.G. McCullough, S.A. Zamudio, A. Micco, T.S. Droma, J.G. Zhang, Y. Ping, A. Cymerman and L.G. Moore. Chronic Mountain Sickness: Breathing and brain blood flow during sleep. FASEB J. 4:A414, 1990.

23. Tharion, W.J., B.E. Marlowe, R. Kittredge, R.W. Hoyt and A. Cymerman. Acute high altitude exposure and exercise decrease marksmanship accuracy. Proceedings of the 32nd Annual Military Testing Association, pp. 408-413, 1990.

PRESENTATIONS:

24. Fulco, C.S. The physiological responses to acute and chronic high altitude exposure. Guest lecturer for the course: Graduate Seminar: Exercise in Stressful Environments. University of Connecticut, Storrs, CT, February 1990.

25. Fulco, C.S. Caffeine consumption, physical performance, and coronary heart disease. Seminar Boston University School of Public Health, Boston, MA, March 1990.

26. Fulco, C.S. Physical performance at high altitude. Current Concepts in Environmental Medicine, USARIEM, May 1990.

27. Iwanyk, E.J. Medical problems at high terrestrial elevation. U.S. Army School of Aviation Medicine, Fort Rucker, AL, February 1990.

28. Iwanyk, E.J. Medical problems at high terrestrial elevation. Current Concepts in Environmental Medicine, USARIEM, May 1990.

29. Iwanyk, E.J. Medical problems at high terrestrial elevation. U.S. Army School of Aviation Medicine, Fort Rucker, AL, October 1990.

30. Iwanyk, E.J. The medical aspects of cold weather operations. 158th Aviation Regiment, Fort Devens, MA, December 1990.

ALTITUDE RESEARCH DIVISION

KEY BRIEFINGS:

31. Eugene J. Iwanyk, MAJ, MC. Medical problems and lessons learned from exercise Fuerzas Unidas Bolivia 89. Major General Philip K. Russell, Commander, U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD, April 1990.

SIGNIFICANT TDY:

Thirteen investigators and supporting technicians from the Altitude Research and Military Nutrition Divisions were temporarily assigned duty at Ft. Riley, KS and Potosi, Bolivia for the period April 1990 and July-August, 1990.

SIGNIFICANT VISITORS:

Dr. Michael Ward, St. Andrew's Hospital, England, July 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Eugene J. Iwanyk, MAJ, MC. Aviation Medicine Officer and General Medical Officer, Cutler Army Hospital, Fort Devens, MA.

Allen Cymerman, Ph.D. Editorial Board, Wilderness Medical Society.

Richard L. Burse, Sc.D. Director, New England Chapter, Human Factors Society.

Richard L. Burse, Sc.D. Judge, Student Paper Award Committee. Environmental and Exercise Physiology Section, American Physiological Society.

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Exposure of significant numbers of troops to a cold environment usually results in various forms of cold injury. The effects are long-lasting, and even mild, apparently innocuous, injury may predispose individuals to a severe freeze injury. Recent reports indicate that the arachidonic acid cascade and prostaglandin/thromboxane release contribute to the outcome of frostbite. A model system has been developed using commercially available artificial human skin. This model was used to determine whether human keratinocytes and fibroblasts, in differentiated dermal-epidermal layers, release interleukin-1α (IL-1α) and a prostaglandin (PGE_2) after a freeze-thaw injury, and to evaluate the ultrastructural integrity of the "living skin equivalent" (LSE). Freezing at 1°C/minute, followed by rapid rewarming of the LSE, resulted in the induction and release of IL-1α and reduced release of PGE_2, as measured in the incubation media 24 hours after the freeze-thaw injury. Analyses of potassium release and ultrastructural evaluation are in progress. Demonstration of one of the specific cellular sources of these compounds and evaluation of the mechanisms involved in the injury process could lead to improved tissue retention after frostbite. Use of the LSE model could also reduce the numbers of animals required for this type of research. The model may also be applicable to studies of heat-induced injury.

2. Infrared thermography was compared to bone scan and radiography to determine its ability to accurately diagnosis stress injury in the lower limbs. Baseline thermograms were taken of 1400 basic trainees prior to the beginning of physical training. Any soldier suffering an injury of the lower limb during training was examined clinically, radiographically and by bone scan, as well as having a second set of thermograms taken. Statistical comparison of baseline and post-injury thermograms demonstrated significant differences between the two, indicating that thermography did detect the change from non-injured to injured. However, when the thermograms were clinically evaluated (not statistically evaluated) and then compared to bone scans, we found a positive predictive value of 100% and a negative predictive value to 66%. This means that a clinically positive thermogram was highly likely to correspond to a positive stress injury (as diagnosed by bone scan), but if the thermogram was negative it was possible that a stress injury could exist but not be thermographically detected. Thermographic results have not yet been compared to radiography.

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

The findings to date differ significantly with findings reported in the literature concerning the usefulness of thermography as a diagnostic tool. The cause of the difference remains to be determined.

3. A research effort was orchestrated between The Institute of Chemical Defense and USARIEM to assess the effects of perspiration on Multishield skin (lotion, cream). This over-the-counter product for protection against poison ivy had proven effective against agent mustard when tested on animals. However, a plausible animal model was not available to test the protector's capability in the presence of sweat.

4. A Cooperative Research and Development Agreement was signed with The Gillette Company to bring together the expertise of both institutions to study the effects of antiperspirants on feet. USARIEM will provide test subjects, equipment, and considerable experience attained by accomplishing a pilot study. Gillette will provide antiperspirant compounds and counsel.

5. The copious volume of fluid required during bypass rewarming and the resulting edema are features associated with attempts to rewarm human hypothermic victims (Medical after Action Conference - Mount Hood Tragedy; Report# T10-88). This suggests that cold exposure contributes to modulation of the endothelial cell barrier. Previously reported in vitro studies have demonstrated that endothelial cell metabolites and cytoskeletal elements that influence permeability are disturbed by hypothermic exposure. A model for endothelial cell barrier function that employed a fluorescently labeled permeability probe (dextran 4000) has been used to study the effects of hypothermia. Exposure to 4°C significantly enhanced passage of this probe between endothelial cells cultured on permeable membranes. This was true for 4°C exposures of 8 and 18 hours. These findings indicate that information generated by this model may contribute to our understanding of the effects of temperature extremes on endothelial metabolic and barrier functions. This system will be further defined and used to identify treatment modalities that support the endothelium during exposure to challenging conditions of environment.

6. Plasma fibronectin influences shock survival; basal levels of fibronectin increase with active conditioning that involves

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

physical exertion in a warm environment. This form of conditioning also results in improved human thermoregulatory capacity. To further study the relationship between basal plasma fibronectin level and thermoregulation, the effects of passive conditioning (seasonal change) were examined in young men. Basal blood volume, basal plasma volume and hot-humid exercise sweat loss were found to be elevated in the summer relative to the spring, which demonstrated that some factors influencing thermoregulation were improved. Though perhaps influenced by the significant plasma volume reductions associated with the elevated sweat loss, the absence of lower maximal heart rates and rectal temperatures, in the summer compared to the spring, suggested that thermoregulatory capacity was not improved with seasonal change. Moreover, seasonal change did not improve basal plasma fibronectin level, since summer and spring values were similar. It appears that increases in basal plasma fibronectin level do not result in the absence of improved thermoregulatory capacity. However, since fluid replenishment to counter the effects of sweat loss may have improved thermoregulation, further study is required to substantiate a correlation between thermoregulatory capacity and basal plasma fibronectin level.

7. When humans are exposed to cold, urinary output is increased. This can result in significant dehydration. This phenomenon is known as cold induced diuresis (CID). The hormonal influences in CID remain unresolved. Atrial natriuretic peptide (ANP) and vasopressin (VP) are counteracting determinants of urine production. ANP increases sodium excretion, which elevates urine flow, while VP augments permeability of the distal tubules in the kidney to decrease urine formation. Four male subjects were exposed to hypothermic (15°C) and normothermic (29°C) conditions on separate days. Plasma ANP and VP levels were determined in conjunction with measurement of urine production and urinary sodium levels. Relative to normothermic conditions, hypothermic exposures resulted in significant elevations of ANP, urinary sodium and urine flow, but no significant changes in VP were observed. These findings suggest a physiological role for ANP in CID.

8. A comparison of the standard operational ration (MRE) with a dehydrated, cold-weather ration (RCW) was made in an arctic environment. Neither ration was superior, either in inducing intake or maintaining water balance. The decision to use the non-freezing ration in place of the standard ration has to be made on

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

tactical considerations and not on nutritional or hydration criteria.

9. Preliminary results indicate that Classical Psychological Conditioning can be useful in reducing the cold hypersensitivity following a freezing injury. There appears to be a better response in hands than in feet.

PUBLICATIONS:

1. Ahle, N.W., J.R. Buroni, M.W. Sharp and M.P. Hamlet. Infrared thermographic measurement of circulatory compromise in trenchfoot injured Argentine soldiers. Aviat. Space Environ. Med. 61:247-250, 1990.

2. Bandick, N.R. and D.E. Roberts. Intrinsic alteration of the reactive properties of arteries during hypothermia. Cryobiology. (In Press).

3. Brown, F.E., M.P. Hamlet, and D.E. Tobin. Acute care and rehabilitation of the hand after cold injury. In: Rehabilitation of the Hand: Surgery and Therapy. J.M. Hunter, L.H. Schneider, E.J. Mackin, and A.D. Callahan. (Eds.). C.V. Mosby Company, St. Louis, 1990, pp. 858-864.

4. Darrigrand, A.A., K. Reynolds, R. Jackson, M.P. Hamlet, and D.E. Roberts. Reduction of sweat accumulation rate with pedal antiperspirants. In: Proceedings Army Science Conference, Durham, NC, June, 1990.

5. Daum, P.S., W.D. Bowers, Jr., J. Tejada, D. Morehouse, and M.P. Hamlet. Cooling to heat of fusion (HOF), followed by rapid rewarming, does not reduce the integrity of microvascular corrosion casts. Cryobiology. (In press).

6. Hamlet, M.P. Cold Injuries, Raynaud's Disease, and Hypothermia. In: Winter Sports Medicine. M.J. Casey, C. Foster, and E.G. Hixson. (Eds.). F.A. Davis Company, Philadelphia, 1990, pp. 148-157.

COLD RESEARCH DIVISION

PUBLICATIONS:

7. Hamlet, M.P. Raynaud's Disease: A Simple Approach to Management. The Phy. and Sports Med. 18:129-132, 1990.

ABSTRACTS:

8. Agnew, J.W. and D.A. DuBose. Fluid shifts during cold exposure. FASEB J. 4(4) :A965, 1990.

9. Agnew, J.W. and D.A. DuBose. Seasonal acclimation does not provide a thermoregulatory advantage while exercising in a humid environment. Med. Sci. Sports Exercise. 22(2) :S118, 1990.

10. DuBose, D.A. Hypothermic effects on endothelial cell prostaglandin synthesis and F-actin. J. Cellular Biochem. 14E:221, 1990.

11. DuBose, D.A. Seasonal effects on human plasma fibronectin modulations during bicycle exercise in a cool environment. FASEB J. 4(4) :A861, 1990.

KEY BRIEFINGS:

12. Murray P. Hamlet, D.V.M. Prevention of Cold Injury, Mountain Warfare School, Vermont National Guard, Jericho, VT, January, 1990.

13. Murray P. Hamlet, D.V.M. Cold Injury, Frostbite and Hypothermia, Sport's Medicine Conference, Lake Placid, NY, January, 1990.

14. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, Army Flight Surgeon Primary 16 Course, 90-2, Fort Rucker, AL, March, 1990.

15. Murray P. Hamlet, D.V.M. Prevention of Cold Injury, Mountain Warfare School, Vermont National Guard, Jericho, VT, March, 1990.

16. Murray P. Hamlet, D.V.M. Environmental Medicine, U.S. Army Operational Aeromedical Problems Course, U.S. Army School of Aviation Medicine, Fort Rucker, AL, March, 1990.

COLD RESEARCH DIVISION

KEY BRIEFINGS:

17. Murray P. Hamlet, D.V.M. Cold Weather Operations, Military Mountaineering Conference, Mountain Warfare School, Vermont National Guard, Jericho, VT, April, 1990.

18. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, U.S. Naval Support Force Antarctica, CBC, Port Hueneme, CA, July, 1990.

19. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, Army Flight Surgeon Primary 16 Course, 90-3, Fort Rucker, AL, July, 1990.

20. Murray P. Hamlet, D.V.M. Cold and Environmental Injuries, Joint Reserve Component Shared Sustainment Training Program, 74th AES, Westover, MA, September, 1990.

21. Murray P. Hamlet, D.V.M. Cold Weather Injury, Prevention, and Treatment, Soldiers and Physicians, Fort Drum, NY, October, 1990.

22. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, Army Flight Surgeon Primary Course 16, 91-1, Fort Rucker, AL, November, 1990.

23. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, ROTC Students, Norwich University, Northfield, VT, November, 1990.

SIGNIFICANT TDY:

James W. Agnew, CPT. To attend FASEB Conference, Washington, D.C., 1-4 April, 1990.

James W. Agnew, CPT. To attend the American College of Sports Medicine Meeting, Salt Lake City, UT, 22-26 May, 1990.

Wilbert D. Bowers, Jr., Ph.D. To attend training course on Advanced Microscopy, Crye-fixation, George Washington University, Washington, D.C., 3-7 June, 1990.

Wilbert D. Bowers, Jr., Ph.D. To attend the Twelfth International Congress for Electron Microscopy, Seattle, WA, 12-18 August, 1990.

COLD RESEARCH DIVISION

SIGNIFICANT TDY:

Andre A. Darrigrand, MAJ. To attend Charles River Laboratory Symposium on Rodent Quality Control and Transgenic Animals, Boston, MA, 21 February, 1990.

Andre A. Darrigrand, MAJ. To attend the American College of Laboratory Animal Medicine: Forum on Anesthesia and Analgesia in Laboratory Animals, Columbia, MD, 3-6 May, 1990.

Andre A. Darrigrand, MAJ. To attend Symposium on Good Laboratory Practices, East Brunswick, NJ, 5-7 November, 1990.

David A. DuBose, Ph.D. To attend Microcirculatory Annual Meeting, Washington, D.C., 31 March - 4 April, 1990.

David A. DuBose, Ph.D. To attend FASEB Annual Meeting, Washington, D.C., 1-4 April, 1990.

David A. DuBose, Ph.D. To attend UCLA Symposium on the Endothelial Cell, Keystone, CO, 6-12 April, 1990.

David A. DuBose, Ph.D. To attend the course on Inmunocytochemistry at the Catholic University of America, Washington, D.C., 18-22 June, 1990.

Elizabeth D. Glass, SPC. To attend Seminar entitled, 'Agricultural Animals in Research", Washington, D.C., 6-8 September, 1990.

Murray P. Hamlet, D.V.M. To participate in meeting of RSG 20/Panel 8 on Modeling Responses to Cold Exposure, NATO Headquarters, Brussels, Belgium, 7-9 February, 1990.

Murray P. Hamlet, D.V.M. To attend International Cold Symposium on Effects of Cold Weather on Combat Performance, Minden, NV, 13-15 February, 1990.

Murray P. Hamlet, D.V.M. To attend the Foreign Medical Materiel Exploitation Conference, Fort Detrick, MD, 10 April, 1990.

Murray P. Hamlet, D.V.M. To participate in Conference on Bering Bridge Expedition, Moscow, Soviet Socialists Republic, 8-16 May, 1990.

COLD RESEARCH DIVISION

SIGNIFICANT TDY:

Murray P. Hamlet, D.V.M. To attend Conference for Information Exchange on Data from Bering Bridge Expedition with Soviet Scientists, Minneapolis, MN, 23-25 October, 1990.

Murray P. Hamlet, D.V.M. To confer on Development of Sock for Soldier Use with representative from Senneca Sock Mill, Senneca, NY, 11 December, 1990.

Donald E. Roberts, Ph.D. To finalize arrangement for the study "A comparison of the Meal, Ready-to-Eat with Supplemental Pack and the Ration, Cold Weather consumed in an arctic environment", Ft. Richardson, AK, and Ft. Wainwright, AK, 15-19 January, 1990.

Donald E. Roberts, Ph.D. To collect hydration and food intake data for the study "A comparison of the Meal, Ready-to-Eat with Supplemental Pack and the Ration, Cold Weather consumed in an arctic environment", Ft. Greely, AK, 29 January - 16 February, 1990.

Donald E. Roberts, Ph.D. To attend annual meeting of FASEB, 29 March - 3 April 1990.

Donald E. Roberts, Ph.D. To attend Army Science Conference, Durham, NC, 10-15 June, 1990.

Donald E. Roberts, Ph.D. To monitor ongoing contract and consult on proposed studies involving assessment of people in the cold by use of the Fire Arms Training System (FATS), Duluth, MN, 7-10 August, 1990.

Donald E. Roberts, Ph.D. To collect data for the protocol "Classical conditioning as a treatment for injury induced cold intolerance", Ft. Wainwright, AK, 3 September - 20 October, 1990.

D. Scott, CPT. To attend Mountain Warfare School, Jericho, VT, 3-17 March, 1990.

D. Scott, CPT and SGT R. Cote. To collect control measurements for Bolivia field study (sea level baseline), Fort Riley, KS, 22-28 April, 1990.

D. Scott, CPT. To attend American Veterinary Medicine Association Convention, San Antonio, TX, 19-26 July, 1990.

COLD RESEARCH DIVISION

SIGNIFICANT TDY:

D. Scott, CPT, SSG M. Sharp, SGT R. Cote. To attend a two day workshop on Neuromuscular Thermographic Interpretation and Technique, Newark, NJ, 14-16 September, 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Michael Blaha, Chairman, Facility Safety Committee.

Michael Blaha, Alternate, Safety Committee, USARIEM.

Michael Blaha, Member, HAZMET Team.

Wilbert D. Bowers, Jr., Ph.D. Chairman, Animal Care and Use Committee, USARIEM.

Wilbert D. Bowers, Jr., Ph.D. Member, Quality Assurance Committee, USARIEM.

Wilbert D. Bowers, Jr., Ph.D. Member, Safety Committee, USARIEM.

Wilbert D. Bowers, Jr., Ph.D. Member, Safety Inspection Team, USARIEM.

David A. DuBose, Ph.D. Member, USANRDEC Radiation Protection Committee.

David A. DuBose, Ph.D. Sigma Xi Program for Regional and State Science Fairs.

Murray P. Hamlet, D.V.M. Member NATO Panel VIII, Research Study Group 20: Modeling Responses to Cold Exposure.

Murray P. Hamlet, D.V.M. 4th International Symposium on the Performance of Protective Clothing, Chairman of Session on Temperature Extremes II.

Murray P. Hamlet, D.V.M. Chairman for Panel on "Treatment modalities of local cold injuries in the field and in the hospital" and guest lecturer for the Nordic Conference on Cold in Tromso, Norway.

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. An objective of Army infantry training is the development of endurance and load carriage ability achieved by frequent running and road marching. A study was conducted using a cohort light infantry unit at Ft. Ord, CA. to determine the incidence of new injuries incurred during load road march training. Potential risk factors for these injuries were also examined. Information about training and past injuries were obtained by questionnaire. A periodic review of medical records was performed to document the incidence of new injuries. Over the observed period, 29% suffered one or more lower extremity training injuries. Trends of significantly increased risk of injury were also observed with increased frequency of running and marching. Those soldiers who had no past injury causing loss of school or work time were at lower risk of current injury (25.6%) than those injured in the last 2 years (44.3%), $p=0.04$). The data suggest that frequent weight-bearing training and recent injuries predispose infantry soldiers to future injury.

2. Despite technical advances in load carriage, the infantry soldier must in many cases depend on his own mobility to move himself and his equipment during combat. This may lead to excessive fatigue and injuries. While studying the physiology of load carriage (HURC #297), we availed ourselves of the opportunity to document load carriage related injuries during prolonged walking (12 km) on a level motor driven treadmill. Since foot blisters are a common marching injury, we also examined the foot morphometric changes that occurred during loaded treadmill marching. Fifteen male subjects marched with the Army's external frame pack system on a level treadmill at these speeds of 3.96, 4.86, 5.76 km/hr, in random order over a 7 week period. Aerobic power ($\dot{V}O_2max$) and body composition (UWW) were measured during the initial week. A large number of minor injuries (N=82) were observed among physically fit soldiers. Injuries primarily involved the lower extremities and back, with foot blistering being the most common injury recorded. We also noted a significant increase in foot ($p<.05$) circumferences during the treadmill march with a tendency for these changes to occur with the heavier loads.

3. Keeping the feet dry is an important preventive measure in decreasing foot blistering during road marches. Moist accumulation around the feet appears to alter the coefficient of friction on the skin interface by altering shearing-absorbing properties.

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

Prolonged dampness may lead to a macerated epidermis and loss of a protective barrier resulting in such lesions as friction blisters. We examined the effect of two antiperspirants on foot-sweat accumulation and frictional blistering. Nineteen male soldiers marched unloaded for one hour on a level treadmill at 5.6 km/hr in a warm environment with and without antiperspirant treatment. Both antiperspirants decreased foot-sweat accumulation by over 50% (p,.05). The antiperspirants also showed a tendency to decrease foot blisters but there was an increased incidence of irritant dermatitis (p<.05).

4. Data analysis has been completed on physical fitness (diagnostic APFT test results), body composition (% body fat and BMI), and incidence of injuries of 2,245 Army basic trainees (1,349) males and 896 females) collected at Ft. Jackson in 1988. Results of this analysis are similar to those from previous studies at Ft. Jackson in 1984 and Ft. Benning in 1987. The incidence of injuries among female trainees was significantly higher than for males, 43.5% for women as compared to 27.2% for men (risk ratio = 1.61, P<.0005). For both men and women the slowest two quintiles (slowest 40%) on the initial 2 mile run test were at significantly greater risk of injury than the fastest three quintiles (fastest 60%). For male trainees the risk ratio for the slowest two quintiles versus the fastest three was 1.3 (30.4%/25.1%, P<.01). For female trainees the risk ratio for the fastest versus the slowest was 1.2 (48%/40.9%, P<.05). Men and women doing the fewest sit ups were also at significantly greater risk of injury than those doing the most. There was also a significantly higher risk of injury among male trainees doing the least push ups, but there was no association between push up performance and risk of injury among female trainees.

The trends of associations between body composition and risk of injury were different for men and women. The quintile of male trainees with the highest % body fat was at significantly greater risk of injury than the lowest risk second quintile, 27.6% vs 19.0% (risk ratio = 1.5, P<.05). For women, just the opposite was true. The quintile with the lowest % body fat was at significantly greater risk of injury than the middle (third) quintile, 44.8% versus 33.9% (risk ratio = 1.3, P<.05). No significant associations between BMI and injury were found among men, while the women with lower BMI's were found to be at significantly greater risk of injury. These data suggest that the physically fittest men

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

and women entering the Army are at lower risk of injury during initial entry training. Also, the fatter men on entry to the Army appear to be at greater risk of injury during IET, while, paradoxically, it appears that the leanest women are at greater risk than more average ones.

5. 1460 male basic trainees were prospectively studied at Ft. Bliss, TX in 1989. To determine the effect of entry level trainee physical fitness and modifications of physical training on the incidence of injuries during Army initial entry training. A questionnaire was employed to determine past physical activity, fitness and job activities of trainees. Height, weight, percent body fat, and flexibility of subjects were measured by USARIEM staff before the onset of Army training. Army Physical Fitness Test results from tests conducted within 3 days of the onset of IET were used to further assess fitness. A significant trend (P=.004) of increasing risk of injury with decreasing levels of self-assessed fitness was observed - risks increasing in stepwise fashion from 10.3% for the excellent fitness group to 23.1% for the poor fitness group, the fourth group. A significant trend (P=.001) of increasing risk of injury with decreasing aerobic fitness as measured by 2 mile run times was also observed - risks increasing from 140% for the fastest quintile to 22.8% for the slowest group. Significant trends of association between successively lower levels of fitness and increasing risks of injury were also noted for body mass index (P=.03) and flexibility (P=.04). In regard to training, 6 companies were assigned to 3 cyclic training (no running in 2nd week of IBT, none in the 3rd or none in the 4th) or to 2 control groups (run every week 3 times per week, low mileage control, or every week every day, a high mileage control. The combined injury rates of the 3 test groups (1 week no running) were 30% higher than the low mileage control (P=.00). The stress fracture rates of both the combined test groups and the high mileage control were higher than the low mileage control, 63% (3.1%/1.9%, P=.2) and 105% (3.9%/1.9%, P=.01). The data indicate that the least fit trainees on entry to the Army are at significantly greater risk of injury than their more fit peers, and that "cyclic training" does not prevent training injuries in general or stress fractures in Data particular.

6. The energy cost of 155 mm Howitzer operations and physiological factors in sustained operations was studied in order to examine the continued effectiveness of 155 mm Howitzer crewmen during a 48 hour

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

scenario with high rates of fire from this study was collected November-December 1989 and has been further analyzed since the last historical report. Subjective measures of mood state, rated perceived exertion (RPE) and physical pain and discomfort as well as objective measurements of arm-hand steadiness, handgrip strength and time to mission completion were made during the scenario. The Profile of Mood States revealed a significant ($p<.05$) increase in fatigue and tension, and a decrease in vigor. There was a significant increase in RPE during the 48 hour scenario for upper body, lower body and overall RPE. The pain and soreness questionnaire revealed a significant increase in muscle soreness in the arm and shoulder areas. Heavy lifting exercise did not result in an increase in pain and soreness of the lower back or legs. The high intensity loading exercise did not affect arm-hand steadiness, indicating that marksmanship performance may not be affected. There was a significant decrease (8.6%) in isometric handgrip strength during the scenario. This decrease in strength may affect the performance of a crewmember who has marginal strength levels for task performance. The time for completion of fire missions decreased significantly from the cycle 1 to cycle 6 of the scenario by 3.6 minutes. Overall results indicated that high rates of artillery fire could be maintained for a 48 hour period. Performance improved in terms of time to completion of fire missions and energy cost. The perception of effort, pain and discomfort and mood were all negatively affected by continuous operations.

7. Effects of a shoulder harness on litter carriage performance and post-carry fatigue of men and women was studied. The initial pilot phase of this study was accomplished during December, 1990. Procedures were established for mounting and dismounting a moving treadmill, and for lifting the loaded litter while on a moving treadmill. The prototype shoulder harness to be used during the main protocol was designed and tested. Instrumentation which allowed the subject to control the treadmill speed and a device to measure the distance of the litter carry were developed by the Biomedical Engineering Branch. A program to record the time parameters and display the distance of the litter carry was written.

8. A comprehensive gait analysis testing procedure was developed which includes the following: 1) three-dimensional high-speed

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filming using two Locam 16 mm cameras, 2) film analysis using in-house developed computer software for film digitizing and mathematical processing, 3) ground contact force and torque assessment using a force platform, 4) muscle electrical activity assessment using self-amplified electrodes, 5) backpack motion analysis using a tri-axial accelerometer, 6) test subject pacing using an in-house designed and fabricated locomotion speed cuing device. The complete analysis integrates time-coordinated data from all the monitoring devices.

9. A system was developed in order to test the efficacy of computerized motor-skill training through augmented feedback. It includes 1) A cycle ergometer fitted with transducers to measure forces on the pedals and position of the pedals and crank, 2) A computer program which calculates and displays non-productive (radial) forces on a computer screen updated 30 times per second, which the test subject attempts to minimize, and 3) A testing protocol designed to assess whether efficiency can be improved through feedback training and at what rate such skill degrades upon cessation of training.

10. In the National Health and Nutritional Examination Survey, body composition was shown to be related to serum lipids and to iron status. A study was conducted in support of a larger nutritional assessment study which examined the relationship of body composition to these biochemical markers of nutritional status in 128 male and 90 female healthy nonsmoking cadet volunteers at the U.S. Military Academy. The body composition of cadets has not changed from that measured in cadets 10 years ago. Mean values of circumferentially-determined body fat were 12% (men) and 26.5% (women); no men and only 14% of the women were overfat by AR 600-9 standards for 21-27 year olds, although by the standards of the Cadet Weight Control Program, half of the women would be classified as overfat. A majority of female cadets (79.5%) and 37% of male cadets in the study population stated that they were attempting to lose weight. Serum lipid profiles indicated low cardiovascular disease risk status for this population; 6% of men and 3% of women in this study exceeded the cholesterol and LDL-cholesterol screening limits recommended by the National Cholesterol Education Program. Skinfold-determined fatness, fasting serum insulin levels, and family history of high blood pressure were the factors most related to higher levels of cholesterol and/or decreased HDL-cholesterol for the males, but fatness was unrelated for the women.

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All measures of iron status indicated deficiency in comparison to the 1979 study of cadets, a direct result of a blood drive which occurred in the week prior to our study; one third of the women were beneficial to various hematological parameters, including those women who gave blood. These findings led to the conclusion that women should not be held to a body fat standard which is more stringent than the current Army standard described in AR 600-9. This may, in part, be encouraging the high prevalence of desired weight loss in these cadets and dieting is known to be associated with deficient intake of essential nutrients such as iron. At the other extreme, excess fat intakes should be discouraged through appropriate dietary education. (ref: T4-91).

11. Data from the 1984-5 Army Body Composition Study was further analyzed to address specific questions asked by the OTSG and DCSPER. Male body fat standards in AR 600-9, including the method of body fat estimation, are well matched to aerobic performance and military appearance standards. Female body fat standards do not match as well to physical performance and military appearance. This is in part, because of the greater variety of body sites for fat storage in women. Some of these sites are not directly related to performance or concepts of military appearance and the variety of these sites of deposition make accurate assessment of total body fat more complicated in women, compared to male soldiers. Based on the relationships between body fat estimated by the method in AR 600-9 to treadmill-tested aerobic performance and military appearance assessed by a command experienced military panel, it was concluded that female body fat standards should be liberalized by +2% body fat units in each of the age categories, with modification of the screening weight tables to appropriately predict the higher body fat. This recommendation along with recommendations for changes to AR 40-501 linking accession body composition standards to the retention standards was endorsed by OTSG and briefed to the DCSPER. The DCSPER agreed with the conclusions but asked for further coordination with TRADOC before any revision to policy is made. (ref: briefing/conference at OTSG; next day briefing to DCSPER; T15-90).

12. A dual x-ray absorptiometer (DEXA) device was obtained in April 1990. This device permits us to measure the total body bone mineral mass which gives us the technical capability to account for a significant portion of the error in conventional body fat estimations from underwater weighing. A direct estimation of

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percent body fat is also possible with this device from estimates of the fat mass from soft tissue. The validity of this capability is being evaluated against a new criterion method of body fat assessment using a four-compartment model of body composition. If the values prove to be valid, this 10-minute whole body scan on individuals without special preparation and in regular clothing may be a suitable replacement and improvement to data obtained from underwater weighing which requires multiple trial measurements of residual volumes and underwater submersion and exhalation maneuvers. The DEXA also has the capability to perform detailed analysis of hip and spine regions for bone mineral mass and planar "density".

PUBLICATIONS:

1. Backous, D., J. Farrow, K. Friedl. Assessment of pubertal maturity in boys using height and grip strength. Journal of Adolescent Health Care 11:497-500, 1990.

2. Fava, M., A. Littman, P. Halperin, E. Pratt, F. Drews, M. Oleshansky, J. Knapik, C. Thompson and C. Bielenda. Psychological and behavioral benefits of a stress/Type A behavior reduction program for healthy middle-aged Army officers. Psychosomatics. (In Press).

3. Friedl, K., J. Dettori, C. Hannan, T. Patience, S. Plymate. Comparison of the effects of high dose testosterone and nandrolone to a replacement dose of testosterone on strength and body composition in normal men. Journal of Steroid Biochemistry (In Press).

4. Friedl, K. Reappraisal of the health risks associated with the use of high doses of oral and injectable androgenic steroids. In: Anabolic Steroid Abuse, G.C. Lin & L. Erinoff (Eds). Research Monograph 102, National Institute on Drug Abuse, Rockville, MD, 1990, pp. 142-77.

5. Friedl, K., J. Vogel, M. Bovee and B. Jones. Assessment of body weight standards in male and female Army recruits. USARIEM Technical Report No. T15-90, 1990.

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

6. Friedl, K. and J. Vogel. Looking for a few good generalized body-fat equations (letter). American Journal of Clinical Nutrition 53. (In Press).

7. Friedl, K., L. Marchitelli, D. Sherman and R. Tulley. Nutritional Assessment of Cadets at the U.S. Military Academy: Part 1. Anthropometric and Biochemical Measures. USARIEM Technical Report No. T4-91, 1990.

8. Friedl, K., C. Hannan, R. Jones and S. Plymate. HDL-cholesterol is not decreased if an aromatizable androgen is administered. Metabolism. 39:69-74, 1990.

9. Friedl, K. Body composition and military performance: Origins of the Army standards. Proceedings of the National Academy of Science, Workshop on Body Composition and Military Performance, National Academy of Sciences, Washington, D.C. (In Press).

10. Hannan, C., K. Friedl, T. Kettler and S. Plymate. Serum homovanillic acid changes after androgenic steroid administration. Psychoneuroendocrinology. (In Press).

11. Harman, E. Body size/composition and biomechanical aspects of task performance. Proceedings of the National Academy of Sciences, Institute of Medicine, Food and Nutrition Board, Workshop on Body Composition and Military Performance. (In Press).

12. Harman, E.A., M.T. Rosenstein, P.N. Frykman, R.M. Rosenstein and W.J. Kraemer. Estimation of human power output from maximal vertical jump and body mass. J. Appl. Sport Sci. Res. (In Press).

13. Harman, E.A. The measurement of human mechanical power. In: Physiological Assessment of Human Fitness. P.J. Maud and C. Foster (Eds.). Human Kinetics, Champaign, Illinois. (In Press).

14. Harman, E.A. The biomechanics of resistance exercise. In: Essentials of Strength Training and Conditioning. T.R. Baechle (Ed.). National Strength and Conditioning Association, Lincoln, Nebraska. (In Press).

15. Harman, E., M. Rosenstein, P. Frykman and R. Rosenstein. The effects of arms and countermovement on vertical jumping. Med. Sci. Sports Exercise. 22(6):825-833, 1990.

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

16. Harman, E., R. Rosenstein, and P. Frykman. A new augmented feedback system for improvement of cycling efficiency. Proceedings of the American Society of Biomechanics 14th Annual Meeting, pp 211-212, 1990.

17. Harman, E.A., and P.N. Frykman. The effects of knee wraps on performance and injury among weight lifters. National Strength and Conditioning Association Journal, 12(5):30-35, 1990.

18. Jacob, W. and K. Friedl. Drug delivery systems for chemical defense. Army Research, Development & Acquisition Bulletin. ISSN 0892-8657: Department of the Army PB 70-90-1, pp 14-16, 1990.

19. Jones, B.H. and W.O. Roberts. Medical management of endurance events: Incidence, prevention and care of casualties. In: Guidelines for the Team Physician. Cantu, R. (Ed.). American College of Sports Medicine, Lea and Febiger, Philadelphia. (In Press).

20. Jones, B.H., M.W. Bovee and J.J. Knapik. The association between body composition, physical fitness, and injury among male and female Army trainees. National Academia of Sciences Symposia on Body Composition and Military Performance, National Academy Press. (In Press).

21. Knapik, J., C. Meredith, B. Jones, R. Fielding, V. Young and W. Evans. Leucine metabolism during fasting and exercise. J. Appl. Physiol. (In Press).

22. Knapik, J., C. Bauman, B. Jones, J. Harris and L. Vaughan. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. Am. J. of Sportsmed. (In Press).

23. Knapik, J, J. Staab, M. Bahrke, K. Reynolds, J. Vogel and J. O'Connor. Soldier performance and mood states following a strenuous road march. Milit. Med. (In Press).

24. Knapik, J., M. Bahrke, J. Staab, K. Reynolds, J. Vogel and J. O'Connor. Frequency of loaded road march training and performance on a loaded road march. USARIEM Technical Report No. T13-90, 1990.

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

25. Knapik, J., J. Staab, M. Bahrke, J. O'Connor, M. Sharp, F. Frykman, R. Mello, K. Reynolds and J. Vogel. Relationship of soldier load carriage to physiological factors, military experience and mood states. USARIEM Technical Report No. T17-90, 1990.

26. Kraemer, W., L. Marchitelli, D. McCurry, B. Mello, J. Dziados, E. Harman, P. Frykman, A. Damokosh, C. Cruthirds, S. Gordon and S. Fleck. Hormonal and growth factor responses to heavy resistance exercise protocols. J. Appl. Physiol. 69(4):1442-1450, 1990.

27. Kraemer, W.J., J.F. Patton, H.G. Knuttgen, C.J. Hannan, T. Kettler, S.E. Gordon, J.E. Dziados, P.N. Frykman, E.A. Harman, and A.C. Fry. The effects of high intensity cycle exercise on sympatho-adrenal medullary response patterns. J. Appl. Physiol. (In Press).

28. Kraemer, W.J., S.E. Gordon, S.J. Fleck, L.J. Marchitelli, R. Mello, J.E. Dziados, K. Friedl, E.A. Harman, C. Maresh, and A.C. Fry. Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. Int. J. Sports Med. (In Press).

29. Kraemer, W., J. Dziados, S. Gordon, L. Marchitelli, A. Fry and K. Reynolds. The effects of graded exercise on plasma proenkephalin peptide F and catecholamine responses at sea level. Eur. J. Appl Physiol. 61:214-217, 1990.

30. O'Connor, J, M. Bahrke, J. Knapik and J. Vogel. Roadmarching and performance. Infantry. pp31-33, May-June 1990.

31. Patton, J.F., W.J. Kraemer, H.G. Knuttgen, and E.A. Harman. Factors in maximal power production and in exercise endurance relative to maximal power. Eur. J. Appl Physiol. 60:222-227, 1990.

32. Patton, J., J. Kaszuba, R. Mello and K. Reynolds. Physiological and perceptual responses to prolonged treadmill load carriage. USARIEM Technical Report No. T11-90, 1990.

33. Reynolds, K., J. Kaszuba, R. Mello and J. Patton. Prolonged treadmill load carriage: acute injuries and changes in foot anthropometry. USARIEM Technical Report No. T1-91, 1990.

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

34. Rice, V. Comparison of the effects of Diphenhydramine and Astemizole on cognitive performance, mood, and perceived performance. In: Proceedings of the Human Factors Society 34th Annual Meeting. Santa Monica, CA: Human Factors Society, pp 598-602,1990.

35. Rice, V. and P. Kemmerling. The impact of the aging U.S. population on the workforce and on workplace design. In: Proceedings of Human Factors in Design for Manufacturability and Process Planning, London, United Kingdom: International Ergonomics Association, pp 347-354, 1990.

36. Rice, V. and P. Sind. The role of human factors in rehabilitation. Human Factors Society Bulletin, 33(2), 4-5, 1990.

37. Rice, V. Book review, Improving VDT Work: Causes and control of health concerns in 1VDT use by S.L. Sauter. Ergonomics Abstracts, Vol. 22/b, 1990.

38. Sharp, M., E. Harman, B. Boutilier, M. Bovee and W. Kraemer. Effects of progressive resistance training on maximal repetitive lifting capacity. Eur. J. Appl. Physiol. (In Press).

39. Tharion, W., E. Harman, W. Kraemer, and T. Rauch. Effects of different resistance exercise protocols on mood states. J. Appl. Sports Sci. Res. (In Press).

40. Vogel, J. Research initiatives in training related musculoskeletal injuries. Journal of the U.S. Army Medical Department. (In Press).

41. Vogel, J. Obesity and its relation to physical fitness in the U.S. Military. Armed Forces and Society. (In Press).

42. Vogel, J. and K. Friedl. Army data: Body composition and physical capacity. Proceedings of the National Academy of Science, Conference on Body Composition and Physical Performance. (In Press).

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

43. Yancey, M., C. Hannan, S. Plymate, I. Stone and K. Friedl. Effect on serum lipids and lipoproteins in continuous or cyclic medroxyprogesterone acetate treatment in postmenopausal women treaded with conjugated estrogens. Fertility and Sterility 54: 778-82, 1990.

ABSTRACTS:

44. Friedl, K., J. Dettori, C. Hannan, T. Patience and S. Plymate. Comparison of the effects of high does testosterone and nandrolone to a replacement dose of testosterone on strength and body composition in normal men, J. Steroid Biochem. 36(Suppl): 105,1990.

45. Friedl, K., J. Vogel, B. Jones and M. Bovee. Body composition changes in male and female Army recruits. Med. Sci. Sports Exerc. 22:S:762, 1990.

46. Friedl, K., J. Vogel and B. Jones. Assessment of body weight standards in Army recruits. 1990 Army Science Conference, Durham, NC, 12-15 June 1990.

47. Harman, E., P. Frykman, M. Rosenstein, M. Johnson, and R. Rosenstein. The relationship of individual torque-velocity curve shapes to sprint running performance. Med. Sci. Sports Exercise. 22(2):S8, 1990.

48. Harman, E., P. Frykman, M. Rosenstein, M. Johnson and Richard Rosenstein. Relationship of anthropometric and strength measures to middle-distance running ability. J. Appl. Sports Sci. Res. 4(3):112, 1990.

49. Knapik, J., J. Staab, A. Damokosh, B. Jones and J. Vogel. Comparison of subjective and objective evaluations of physical fitness. Med. Sci. Sports Exercise. 22:S116, 1990.

50. Kraemer, W. and K. Friedl (joint plenary lecture presentation). Anabolic hormones, sports medicine and behavior. Neuroendocrinology Letter 12:200, 1990.

EXERCISE PHYSIOLOGY DIVISION

ABSTRUCTS:

51. Kraemer, W., S. Gordon, L. Marchitelli, R. Mello, E. Harman, P. Frykman and J. Dziados. Hypo-pituitary responses to heavy resistance exercise. J. Appl. Sports Sci. Res. 4(3):103, 1990.

52. Kraemer, W., J. Patton, J. Dziados, A. Fry and S. Gordon. Compatibility of conventional strength and endurance programs. Med. Sci. Sports Exercise. 22(2) Suppl: S19-1990.

53. Reynolds, K., A. Darrigrand, R. Jackson, D. Roberts and M. Hamlet. Effects of pedal antiperspirants on sweat accumulation. Med. Sci. Sports Exercise. 22:S781, April 1990.

54. Roloff, J., J. Zoltick, J. Knapik,, F. Drews and P. Harig. Cardiovascular screening and fitness assessment in middle aged Army officers. Med. Sci. Sports Exercise. 22:S95., 1990.

55. Vogel, J., K. Friedl and P. Fitzgerald. Generalized prediction of body fat in young U.S. females. Med. Sci. Sports Exercise 22:S112, 1990.

PRESENTATIONS:

56. Friedl, K. NSCA program to eliminate performance enhancing substance abuse. NSCA National Conference. San Diego, CA, 30 June 1990.

57. Hannan, C.J., K. Friedl and S. Plymate. Effects of testosterone on apomorphine induced movements in the rat. Workshop Conference on Androgen Therapy: Biologic and Clinical Consequences. Marco Island, FL, 17-20 Janaury 1990.

58. Harman, E. Body size/composition and biomechanical aspects of task performance. National Academy of Sciences Institute of Medicine Food and Nutrition Board Workshop on Body Composition and Military Performance. Washington D.C., February 1990.

59. Harman, E., P. Frykman, M. Rosenstein, M. Johnson, and R. Rosenstein. The relationship of individual torque-velocity curve shapes to sprint running performance. ACSM Annual Meeting. Salt Lake City, UT, May 1990.

EXERCISE PHYSIOLOGY DIVISION

PRESENTATIONS:

60. Harman, E., P. Frykman, M. Rosenstein, M. Johnson and Richard Rosenstein. Relationship of anthropometric and strength measures to middle-distance running ability. NSCA Annual Meeting. San Diego, CA, June 1990.

61. Harman, E. The three-dimensional relationship between torque, velocity and joint angle. Neuromuscular Research Center Seminar Series. Boston University, Boston, MA, March 1990.

62. Jones, B. Fatness, fitness and injury among Army trainees. National Academy Science Committee on Nutrition. NAS, Washington, D.C., 6 February 1990.

63. Jones, B. Training-related injuries in military populations. Armed Forces Epidemiology Board. Guests of board included Assistant Secretary of Defense, Dr. Mendez; the Surgeon General of the Army, LG Ledford; the Surgeon General of the Navy and the Commander of MRDC, MG Russell. WRAIR, Washington, D.C., 23 February 1990.

64. Jones, B. Incidence and risk factors for training-related injuries in military populations. Grand Rounds, Beaufort Navy Hospital. Beaufort, SC., 21 March 1990.

65. Jones, B. Physical training-related injuries. Current concepts in environmental medicine course. USARIEM. Natick, MA, 17 May 1990.

66. Jones, B. Case discussion of stress fracture diagnosis. Annual meeting of the American College of Sports Medicine. Salt Lake City, UT., 23 May 1990.

67. Jones, B. Medical threats to Operation Desert Shield. Deploying medical units at Ft. Sill, OK, 21-29 August 1990; Ft. Devens, MA, 20 August-3 September 1990; Ft. Meade, MD, 6 September 1990; Ft. Leonard Wood, MO, 12 September 1990.

68. Rice, V. The interrelationship of ergonomics and occupational therapy: Worksite Evaluation. United States Army Environmental Hygiene Agency Principles of Ergonomics Course. Baltimore, MD, July/August 1990.

EXERCISE PHYSIOLOGY DIVISION

PRESENTATIONS:

69. Rice, V. The role of the Army Medical Specialist Corps in research at the United States Army Research Institute of Environmental Medicine. U.S. Army representative meeting, American Occupational Therapy Conference, New Orleans, LA, April/May 1990.

70. Vogel, J., K. Friedl and P. Fitzgerald. Generalized prediction of body fat in young U.S. females. American College of Sports Medicine Annual Meeting. Salt Lake City, UT, 22-25 May 1990.

71. Vogel, J. Physical fitness research. Advance Course, Army War College. Carlisle Barracks, PA, 2 April 1990.

72. Vogel, J. Body composition and physical capacity in U.S. Army personnel. National Academy of Science Workshop on Body Composition. Washington, D.C., 6 February 1990.

73. Vogel, J. Body composition standards in the Army. DoD Psychology Symposium. USAF Academy, Colorado Springs, CO, 18 April 1990.

KEY BRIEFINGS:

74. Karl E. Friedl, CPT, Ph.D. Accession weight study. Briefing to LTG Ono, DCSPER, Pentagon, Washington, D.C., July 1990.

75. Katy L. Reynolds, MAJ, MD. A prospective longitudinal study of new cohort FORSCOM units to determine injury rates and potential predictors of injury associated with physical training. LTC Bausch, Division Surgeon, 7th Med. and LTC Ambrose, Chief of Physical Therapy, Ft. Ord, CA, February 1990.

76. Katy L. Reynolds, MAJ, MD. The epidemiology of physical training injuries in a U.S. Army light infantry cohort unit. COL Plummer, Chief of Staff, 10th MTN Division; LTC Babbit, Commander of 2nd Bn, 14th Infantry Regiment; and LTC Roberts, Wilcox Hospital Commander, Ft. Drum, NY, May 1990.

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KEY BRIEFINGS:

77. Katy L. Reynolds, MAJ, MD. Briefing of study regarding injury rates and potential predictors of injury associated with physical training among light infantry units. COL. Tuer, Acting Hospital Commander, Silas B. Hayes Community Hospital; MAJ Filaberty, 2nd Bn Executive Officer and Acting Commander, 9th Infantry Regiment; Ft. Ord, CA, June 1990.

78. Katy L. Reynolds, MAJ, MD. Briefing of study regarding injury rates and potential predictors of injury associated with physical training among light infantry units with different training programs. COL Burney, 2nd Brigade Commander, 7th Infantry Division; LTC Wilson, 5th Bn Commander, 21st Infantry Regiment; LTC Swanneck, 2nd Bn Commander, 9th Infantry Regiment; Ft. Ord, CA, October 1990.

79. Joseph Knapik, CPT, Sc.D. Physiological Factors in Load Carriage. Briefing to Combat Controller/Pararescue Road March Working Group, Pope Air Force Base, Ft. Bragg, NC, 10 May 1990.

80. Joseph Knapik, CPT, Sc.D. Epidemiology of Injuries and Illnesses in senior military officers. Briefing to Staff of U.S. Army Physical Fitness Research Institute and Command Group of Dunham Army Health Clinic, Carlisle Barracks, PA, 19 July 1990.

81. Bruce H. Jones, LTC, MD, MPH. Injury surveillance and prevention in military training populations. Briefing to the Chief Executive Officer, Beaufort Navy Hospital (CAPT Cowan) and Division Surgeon (COL Muller) from Camp LeJune, NC at Beaufort Navy Hospital, SC, 21 March 1990.

82. Bruce H. Jones, LTC, MD, MPH. Injury risks and approaches to prevention. Briefing to the Commander, Parris Island Recruit Depot (MG Lynch) and Staff, Beaufort Navy Hospital Commander (CAPT Campbell) and others, 21 March 1990.

SIGNIFICANT TDY:

Bruce H. Jones, LTC, MD, MPH. Trip to conduct surveillance on the incidence of injuries among marine recruits and to consult with staff of Beaufort Naval Hospital on the design of a study to determine causes of injury among recruits. MRCD, Parris Island, SC, 20-22 March 1990.

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SIGNIFICANT TDY:

Bruce H. Jones, LTC, MD, MPH and Joseph Knapik, CPT, ScD. Trip to collect medical data on Senior U.S. Military Officers enrolled at the Army War College (AWC). Carlisle, PA, 24-26 July 1990.

Bruce H. Jones, LTC, MD, MPH. Travel to Academy of Health Sciences to assume leadership of Army briefing teams tasked with developing briefing materials on the Medical Threat to Operation Desert Shield and with briefing medical units deploying to Southwest Asia. Ft. Sam Houston, TX, 15 August - 21 September 1990.

Joseph Knapik, CPT, Sc.D. Participate in Working Group Meeting on Combat Controller/Pararescue Road Marching Study. Pope Air Force Base, NC, 9-11 May 1990.

Joseph Knapik, CPT, Sc.D. and staff of 1. Conduct field study to obtain data on epidemiology of injuries and illnesses in senior military officers. Carlisle Barracks, PA, 25 July - 31 August 1990, 19-21 November 1990.

Katy L. Reynolds, MAJ, MD. Supervision of study: A prospective longitudinal study....injury rates and potential predictors of physical training injuries. Ft. Ord, CA, 9-18 October 1990.

Valerie J. Rice, MAJ, Ph.D. Attend Military Entrance Physical Strength Capacity Test (MEPSCAT) Working Group meeting, Washington, D.C., 15-16 April 1990.

Valerie J. Rice, MAJ, Ph.D. Attend Health Services Command planning meeting for research on prevention and remediation of back injuries. San Antonio, TX, 8-10 February 1990.

Valerie J. Rice, MAJ, Ph.D. Attend Ergonomics Planning Meeting of the Industrial Hygiene Agency. Aberdeen Proving Ground, MD, May 1990.

Marilyn A. Sharp, MS. Attend Military Entrance Physical Strength Capacity Test (MEPSCAT) Working Group Meeting. Washington, D.C., 16 April 1990.

James A. Vogel, Ph.D. Chair NATO Research Study Group on Physical Training. Munich, Germany, 18-22 June 1990.

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SIGNIFICANT TDY:

James A. Vogel, Ph.D. Attended National Conference on Military Physical Fitness. Washington, DC, 25-26 June 1990.

James A. Vogel, Ph.D. Attended Psychology in DoD Symposium. U.S. Air Force Academy, CO, 18-20 April 1990.

James A. Vogel, Ph.D. Attended Symposium on Directions in Nutrition and Food Science. National Academy of Science, Washington, D.C., 12 December 1990.

James A. Vogel, Ph.D. Attended NATO Panel 8 Meeting and presented RSG report. Brussels, Belgium, 25-27 April 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Everett Harman, Ph.D. Adjunct Assistant professor: Sargent College of Allied Health Professions, Boston University.

Everett Harman, Ph.D. Associate Editor: National Strength and Conditioning Association Journal.

Everett Harman, Ph.D. Associate Editor: Journal of Applied Sports Science Research.

Everett Harman, Ph.D. Associate Editor: Conditioning for Volleyball.

Everett Harman, Ph.D. Member, Research Committee: National Strength and Conditioning Association.

Everett Harman, Ph.D. Member, Tests and Measurements Committee: National Strength and Conditioning Association.

Everett Harman, Ph.D. Member, Awards Committee: New England American College of Sports Medicine.

John F. Patton, III, Ph.D. Associate Editor: Journal of Applied Sports Science Research.

Valerie J. Rice, MAJ, Ph.D. Army Medical Specialist Corps Research Advisory Group.

EXERCISE PHYSIOLOGY DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Valerie J. Rice, MAJ, Ph.D. Administration and Special Expertise Representative to the American Occupational Therapy Association.

Roster of Accreditation Evaluators, 3 year appointment.

Valerie J. Rice, MAJ, Ph.D. Human Factors Society: Special Interest Group on Medical Systems and the Functionally Impaired, editorial ardd.

Valerie J. Rice, MAJ, Ph.D. Association for the Advancement of Medical Instrumentation, Human Engineering Committee.

Valerie J. Rice, MAJ, Ph.D. Book reviewer, Ergonomics Abstracts, International Ergonomics Association.

Valerie J. Rice, MAJ, Ph.D. USARIEM Risk Management Committee.

Valerie J. Rice, MAJ, Ph.D. Army Medical Specialist Corps Mentorship Program.

James A. Vogel, Ph.D. Adjunct Professor, Boston University, Department of Allied Health Professions.

James A. Vogel, Ph.D. Member, Massachusetts Criminal Justice Training Council Advisory Panel on Health and Physical Fitness.

James A. Vogel, Ph.D. Associate editor: Journal of Applied Sports Scientific Research.

James A. Vogel, Ph.D. Chairman, NATO Research Study Group on Biomedical Aspects of Military Training.

James A. Vogel, Ph.D. Member, Army Planning Committee for Physical Fitness.

James A. Vogel, Ph.D. Member, Army Counterpart Panel on Board of Army Science and Technology Study of Strategic Technologies (BAST-STAR).

James A. Vogel, Ph.D. Chairman, Credentials Committee, American College of Sports Medicine.

EXERCISE PHYSIOLOGY DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

James A. Vogel, Ph.D. Member, Research Awards Committee, American College of Sports Medicine.

James A. Vogel, Ph.D. Member, Board of Trustees, New England Chapter of the American College of Sports Medicine.

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. A unique, state-of-the-art Neuroscience laboratory is now fully functional. The laboratory assesses the effects of environmental stressors on brain function and develops pharmacologic and nutritional strategies to protect soldiers from adverse effects attributable to such stressors. Studies integrating neurochemical, histochemical and behavioral observations can now be conducted. Techniques such as *in vivo* microdialysis, autoradiography and computerized image-analysis have been mastered and integrated into a series of ongoing studies. One such study, initiated in CY90, has been designed to correlate morphological changes with behavioral and neurochemical alterations produced by exposure to hypoxia and develop new treatment strategies.

2. A study was conducted to determine whether the calcium-channel blocker, nimodipine, improved cognitive function in young rats. Definite improvements in learning and memory were observed. In the same animals the brain neurotransmitter acetylcholine was measured using in vivo microdialysis and found to be elevated. An abstract describing these findings was presented at the Society for Neuroscience and a full length paper submitted for clearance. In CY 91 the beneficial effects of this drug will be examined in animals exposed to hypobaric hypoxia.

3. A study was conducted to evaluate interactions between the performance-enhancing drug amphetamine and a biologically active peptide (Cyclo (His-Pro)) in rats. Cyclo (His-Pro) attenuated the dopaminergic response to d-amphetamine as assessed by microdialysis.

4. A study was conducted to determine whether tyrosine pretreatment reverses hypothermia-induced behavioral depression. Cold exposure accelerates the firing frequency of norepinephrine (NE) neurons, enhancing NE release and leading to NE depletion in specific regions of the brain. The reduction of brain NE is accompanied by a behavioral depression on the open field test. Two experiments were performed on adult male rats. First, it was determined whether systematic lowering of core body temperature produced behavioral depression in the swim test. Second, treatment with the NE precursor, tyrosine, was employed in an attempt to prevent hypothermia-induced behavioral depression. In Experiment 1, two levels of hypothermia were highly effective in producing behavioral depression in rats forced to swim in a narrow cylinder.

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In Experiment 2, treatment with tyrosine (400 mg/kg, IP) thirty minutes prior to the hypothermia procedure completely reversed the behavioral depression found in Experiment 1. Tyrosine administration did not significantly influence the rate of deep body cooling during the cold exposure treatment. This study suggests that tyrosine may protect soldiers from the adverse effects of exposure to hypothermic environments.

5. A study of nine male soldiers was conducted to examine the effects of Benadryl (50 mg) and Seldane (60 mg) on central nervous system functioning. Benadryl is an antihistamine with sedative side effects which crosses the blood brain barrier, while Seldane is purported not to have sedative side effects and not to cross the blood brain barrier. The Pattern Reversal Evoked Potential (PREP) and the Brainstem Auditory Evoked Response (BAER) were used to assess possible effects. A double-blind, within subject, latin square design with a 48 hour washout period was used. BAERs and PREPs were collected 30 minutes after drug administration and repeated every 45 minutes for a total of 4 cycles. Two-way (Drug X Cycle) repeated measures analyses of variance were applied to the data. No significant effects of drug or cycle existed on the BAER. A significant effect of drug was found on the PREP with Benadryl exhibiting longer latencies on the P100 and the N145 wave. A drug by cycle interaction for the N75 wave was found with Benadryl having a longer latency at Cycle 2 (75 minutes post drug ingestion). These results indicate a slowing of visual information processing. This is particularly significant because it identifies the possible neurological site, the visual cortex, affected by this drug. Furthermore, it helps explain on a neurophysiological basis the impairments in visual vigilance found in this laboratory previously with Benadryl.

6. Adaptation of the Weaponeer M16 Rifle Simulator for assessment of soldier performance in the laboratory has proven successful. This development permits the systematic evaluation of rifle marksmanship under controlled environmental conditions, such as heat and cold, and also allows for the evaluation of marksmanship when the soldier is subjected to procedures (medications, cold weather clothing, chemical protective clothing) which are designed to protect against environmental threats. As configured for the laboratory, the Weaponeer permits evaluation of both rifle marksmanship speed (ability to detect and to hit rapidly appearing

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pop-up targets) and accuracy (the variability, or "tightness," of the shot group). Research conducted at USARIEM with the Weaponeer shows (a) that rifle marksmanship speed is impaired by the wearing of chemical protective clothing (MOPP-IV) and by the use of standard nerve agent antidote (600 mg 2-PAM chloride, 2 mg atropine sulfate), and (b) that rifle marksmanship accuracy is impaired by ambient heat (95^{o}F). Assessment of rifle marksmanship on the Weaponeer during 3 hours of simulated sentry duty has shown (a) that speed of target detection is slowed as the amount of time on sentry duty increases, and (b) that both speed of target detection and marksmanship accuracy are impaired by 50 mg diphenhydramine (Benadryl, a commonly used antihistamine which crosses the blood brain barrier) but neither measure of marksmanship is impaired by 60 mg terfenadine (Seldane, a prescription antihistamine which does not cross the blood brain barrier). The Weaponeer laboratory set-up has recently been modified to permit automatic computer administration of rifle marksmanship tasks, as well as automatic collection and storage of the Weaponeer marksmanship data.

7. A study was conducted to assess the effects of three different clothing ensembles on the soldier's rifle marksmanship ability. Soldier performance on simple sensory and psychomotor tasks has been shown to be impaired by the bulkiness of combat clothing and equipment. Since rifle marksmanship is a complex task requiring the coordination of simple sensory and psychomotor skills, it was hypothesized that combat clothing would also impair this task which is so critical to successful soldier performance and survival. Each of 30 male soldier volunteers, matched on rifle marksmanship ability, was assigned to one of three clothing conditions of increasing bulk: battle dress uniform (BDU), fighting load, or MOPP-IV chemical protective clothing. After four days of practice on the Weaponeer M16 rifle simulator, soldiers were assessed on marksmanship for pop-up targets while dressed in the respective combat clothing, both with and without the rifle being supported. Results of a 3 x 2 (clothing x rifle support) analysis of variance showed that (a) regardless of clothing condition, marksmanship was significantly better when the rifle was supported than when it was not supported; and (b) rifle marksmanship was significantly poorer under the MOPP-IV chemical protective clothing condition than under either the fighting load condition or the BDU condition.

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8. A study was conducted to evaluate the influence of total dietary salt intake (4 g per day vs. 8 g per day) on soldiers' marksmanship performance during heat acclimation. Seventeen soldiers underwent a 7 day dietary stabilization period (no heat exposure) during which time they received training on the Weaponeer M16 marksmanship simulator. Following this stabilization period soldiers were exposed to 10 days of a simulated desert environment (8 h per day at 41 deg. C., 20% relative humidity, walking at 5.6 km/h for 30 min/h). Marksmanship measures were average distance of shots from center of mass and of shot group dispersion (tightness) when firing at a simulated 25 meter zeroing target and the ability to hit popup targets at simulated distances of 100 meters and 250 meters. A two-way analysis of variance, Diet (4 and 8 g salt) X Days (1-10), was used to analyze marksmanship effects. Neither salt intake nor the effect of days of walking in the heat nor their inetraction affected marksmanship performance indicating that marksmanship performance remains stable during heat acclimation, regardless of salt intake (4 g vs. 8 g per day).

9. A study was conducted to evaluate the influence of total dietary salt intake (4 g per day vs. 8 g per day) on soldiers' subjective reports of symptoms of heat illness during heat acclimation. Seventeen soldiers underwent a 7-day dietary stabilization period (no heat exposure) and 10 days of heat acclimation (8 h per day at 41 deg. C., 20% relative humidity, walking at 5.6 km/h for 30 min/h). Subjective reports of heat illness were assessed by means of the daily administration of the USARIEM Environmental Symptoms questionnaire (ESQ). The results indicate that regardless of diet the predominant symptoms during heat acclimation are warmth, sweatiness, weakness, irritability, restlessness, and rapid heart beat, with dizziness and disturbed coordination occurring most often during the first two days of heat acclimation. However, subjects on the 8-g salt diet experienced fewer symptoms (the predominant symptom was tiredness) than did subjects on the 4-g diet (predominant symptoms included irritability, weakness, constipation, rapid heart beat, restlessness, and thirst). The formulation and analysis of an ESQ-derived overall index of subjective heat illness showed (a) that each group independently responded to the heat such that by the fourth day of heat exposure subjective heat illness had reached a level which did not differ from any of the succeeding days, i.e., the soldiers had acclimated, and (b) that the two dietary groups differed only during the first

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two days of heat exposure, with soldiers on the 4-g salt diet reporting more subjective heat illness.

10. A study was conducted to evaluate the influence of amount of carbohydrate in the diet (250 g vs. 400 g vs. 550 g of carbohydrate per day) on soldiers' marksmanship performance after a load-bearing forced march. Eighteen soldiers underwent two weeks of treadmill training with a loaded rucksack and marksmanship practice with the Noptel ST-1000 rifle simulator. Following training, soldiers received one of the 3 experimental diets for 4 days. Soldiers served as their own controls. On the final day soldiers participated in up to a four hour load bearing forced march (walking at 3.5 k/h for 50 min/h with a 45 kg load). Marksmanship measures were distance from center of mass, shot group tightness and sighting time. A two-way analysis of variance, Diet (250, 400, and 550 g carbohydrate) X Administration (prewalk and postwalk), was used analysis. Decrements in shot group tightness after the forced march were apparent when soldiers were on a low carbohydrate diet. In addition, sighting time was longer for those soldiers on a low carbohydrate diet. The results indicate that marksmanship performance is impaired after a loadbearing forced march in those soldiers who are on a low carbohydrate diet (250 vs. 400 or 550 g per day).

11. Thirty personnel participating in an armor field study at Fort Knox, KY, in 1989, were administered pills containing either L-tryptophan (an essential amino acid found in many foods) or a placebo to determine if L-tryptophan would improve sleep. Two days after the study was completed, the Food and Drug Administration issued a press release alerting consumers to temporarily discontinue use of L-tryptophan as a food supplement. A few days earlier, doctors had reported more than 30 cases of a blood disorder characterized by intense eosinophilia (high white cell count). Although L-tryptophan was used for many years, no major ill effects from its use had been reported previously. Ten days after the press release, 360 cases were reported; most took L-tryptophan. To determine if soldiers who took L-tryptophan in the armor test were affected, Army medical personnel evaluated them twice 30 and 180 days after the test. Assays of blood samples did not indicate eosinophilia-myalgia. Subsequent scientific investigations by other personnel suggested these cases of eosinophilia-myalgia usually resulted from contaminated L-

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tryptophan produced by one of six world manufacturers. Also, an unidentified peak on chromatograms from suspect batches was found to be related to incidence of the disorder. Since our L-tryptophan was from a different manufacturer than the one whose product was suspected of causing eosinophilia-myalgia, ingestion of L-tryptophan by armor personnel in our test did not increase their risk for eosinophilia-myalgia. We sent certified letters to all soldiers in the study and informed them of this information; we also informed soldiers given L-tryptophan that this new information was being entered into their medical records.

12. In rodents, administration of tyrosine, a food constituent and precursor of the catecholamines, ameliorates some of the behavioral and neurochemical deficits caused by exposure to acute stressors. In an initial study, tyrosine (100 mg/kg, p.o.) protected soldiers from some adverse behavioral effects of 4.5 h exposure to a combination of hypoxia (4200 m and 4700 m altitude equivalent) and cold (15°C) (Banderet and Lieberman, Brain Res. Bull., 22:759-762, 1989). To extend these findings we conducted a dose-response study using similar environmental conditions (4700 m and 17°C) and increased the exposure duration to 7 h. Using a double-blind, placebo-controlled crossover design, we administered 85 and 170 mg/kg of tyrosine p.o. to 21 soldiers. Cognition, symptoms and affect were assessed using: Bakan vigilance task, visual pattern recognition, Environmental Symptom Questionnaire (ESQ) and Profile of Mood States (POMS). Among volunteers with the greatest response to the stressors, both doses of tyrosine significantly ($p<.05$) reduced the adverse behavioral effects of exposure to the stressors. Vigilance, pattern recognition, distress (ESQ), alertness (ESQ), depression (POMS) and confusion (POMS), were less impaired when tyrosine was given. This study confirmed that tyrosine has beneficial effects on soldiers exposed to high altitude and cold stress.

13. Results from a field study conducted with the Nutrition Division demonstrated that reduced levels of the neurotransmitter precursor, tryptophan, predicted performance decrements in soldiers. We studied male soldiers who consumed a calorie-deficient (CD) ration and a calorie-adequate (CA) control ration for 30 days during a U.S. Army field training exercise. Mean daily energy intake was 1950 kcal for the CD group and 2800 kcal for the CA group. Blood was sampled and psychomotor performance assessed

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at the start and completion of the study. Previously we had noted that plasma levels of the neurotransmitter precursors tryptophan and tyrosine decreased significantly in the CD but not the CA group (FASEB J. 3(3):A463, 1989). To determine whether altered precursor availability was related to changes in performance over the course of the study, linear regression was employed, with changes in amino acid ratios (tryptophan or tyrosine divided by the sum of the other large neutral amino acids) as predictor variables and behavioral changes as dependent measures. Decrements in tryptophan ratio were associated with impairments of simple visual reaction time and choice visual reaction time. Decreased availability of tryptophan to the brain reduces synthesis of serotonin and may account for some of the adverse behavioral changes associated with undernutrition. This information should be utilized when lightweight field rations are formulated.

14. Symptom and mood changes were systematically assessed over a period of seven days during an ascent to 3,630 meters. Seven symptom factors (as measured by the Environmental Symptoms Questionnaire) and two mood factors (as measured by the Profile of Mood States) were found to be adversely affected over time by the changes in altitude. More specifically, at higher elevations the subjects experienced more respiratory acute mountain sickness (AMS), exertion stress, and muscular discomfort and were also colder, less alert, less vigorous, and more fatigued. These changes occurred primarily at 3,630 m and most also occurred at 3,080 m. Therefore, a climb to 3,630 m produces adverse changes in symptomatology and mood states, and factors other than just level of altitude can affect these parameters.

15. The Environmental Symptoms Questionnaire (ESQ) provides a systematic and quantitative measurement of symptoms resulting from exposure to various climatic or stressful conditions. The questionnaire yields factor scores for nine distinct symptom groups. The computational procedures for one of the factors, alertness, were found to be incorrect as reported in the original manuscript and were corrected in a supplemental report. The new scores fall within the scale range and are behaviorally more accurate. The use of these procedures is recommended to calculate the value for the alertness scale whenever the ESQ is scored.

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16. When people travel to terrestrial altitudes greater than 3000 m, their physiological and psychological well-being, mental processes, senses, sleep, and physical work capacity are impaired to some extent. Within 4-12 hours, acute mountain sickness and its discomforts usually result. Fortunately, given sufficient time, normal compensatory processes reduce many adverse effects caused by moderate exposure to high altitude. The physiological and psychological limitations associated with exposure to high altitude and some behavioral strategies used to lessen their effects are described in a chapter by two USARIEM researchers to be published in 1991 by J. Wiley and Son in the Handbook of Military Psychology.

17. Effects of nerve agent antidote (2 mg atropine/600 mg 2-PAM chloride versus saline placebo) and heat-humidity (95°F/60%RH versus 70°F/30%RH) on repeated performance of militarily relevant psychological tasks were assessed over 6 h while wearing the battle dress uniform (BDU) and while wearing chemical protective clothing (MOPP-IV). All BDU heat sessions were completed, but with some task impairments and a few subjective reactions. MOPP-IV heat sessions could not be continued beyond two h; all tasks were impaired and subjective reactions were numerous and severe. Atropine/2-PAM significantly shortened endurance time for heat sessions in MOPP-IV. Intensive analysis of subjective reactions and symptomatology indicated that reported symptoms were due primarily to heat rather than to drug effects, but some visual and somesthetic reactions typical of atropine were also noted. Elevated heat stress caused by wearing MOPP-IV at 95°F (35°C) and 60% RH significantly increased the frequency and severity of reported symptoms, compared to wearing only the BDU under otherwise parallel conditions. Claustrophobic reactions due to encapsulation in MOPP-IV, which have been reported in other studies, were not observed. Analysis of visual acuity, phoria, stereopsis and contrast sensitivity indicated that acuity and phoria were significantly impaired by drug in the BDU conditions. Acuity, phoria and stereopsis were all significantly impaired by heat, drug and continued exposure under MOPP-IV. Acuity was significantly impaired by drug even during the first two hours of heat exposure in MOPP-IV. Contrast sensitivity was impaired mainly by heat exposure in MOPP-IV.

18. A comprehensive review of the available knowledge and research findings concerning effects of hot and cold environments on

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military performance was prepared for inclusion in the Handbook of Military Psychology. This chapter reviews known basic human physiological and psychological reaction mechanisms to heat and cold, summarizes and tabulates significant findings on performance capabilities and limitations, and makes relevant practical recommendations regarding military operations in extreme climatic environments.

19. In addition to a previous determination that females had more difficulty than males in sustaining cognitive performance in the heat when clad in MOPP-IV, it was found that both males and females had difficulty with cognitive performance in MOPP-IV at 55 degrees F. over a seven-hour exposure.

20. Personnel from the Health and Performance Division developed an approach for choosing a portable computer to administer the Unified Tri-Service Cognitive Performance Assessment Battery (UTC-PAB) to military personnel. The selection of a computer for assessment of symptoms, moods, and demographics is not critical. In contrast, selection of a portable computer for assessment of cognitive and military performance requires careful consideration of display and other equipment variables that affect the validity of performance data to be collected. Indices of human performance that are rate-dependent require a portable computer with specific characteristics if such measures are to have superior psychometric properties. First, we consider the psychophysical properties of the display. The criteria of intensity, size, contrast, and resolution of a display exclude many portable computers, favoring those with VGA, gas plasma displays. Additional criteria are: MS-DOS, expansion-slot capability, single unit device (self-contained), >640 kbytes RAM, $\geq$20 Mbytes hard disk, transportability, and ruggedness. Tradeoffs are unavoidable particularly with respect to size, weight, portability, battery operation, cost, and connectivity of special keyboards. This approach yields a portable computer for assessment of human performance with an exceptional display, accurate timing for behavioral latencies and event sequencing, capabilities for field and laboratory applications, and potential for future, more advanced performance tasks. Portable computers, selected with this approach, should provide a useful, standardized metric for assessing human performance in challenging environments.

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21. When developing performance tasks, researchers are confronted with a number of choices which may affect the task's measurement properties. To evaluate the effects of test medium, subjects completed Number Comparison (NC) tasks administered with portable computer and paper-and-pencil media. Computerized NC proved superior to paper-and-pencil NC: it had greater completion rates, task reliabilities, and sensitivity to an environmental stressor (hypoxia). In a study investigating task format, subjects were tested with a computerized NC task which presented either 1 problem or 33 problems in each display window. Although the results were similar for these two formats, the response rates for the multiple problem format were 10% greater. Thus, evaluation of performance tasks during development helps ensure their reliability, sensitivity, and other useful psychometric properties.

22. Self-rated measures of symptoms and moods are especially sensitive to stressors and often detect changes in well-being before more objective indices. A 40-item Subjective States Questionnaire (SSQ) was developed to exploit such measurement properties in our research program for determining the effects of extreme environments and evaluating associated treatment strategies. The SSQ assesses a greater range of reactions than symptom or mood scales, evaluates military tasks and common activities relevant to junior enlisted soldiers, and seeks estimates of a soldier's capacity to perform such tasks or the effort required to complete them. SSQ data were collected along with Environmental Symptom Questionnaire (ESQ) data during six, 135-minute test sessions in a laboratory study of heat stress conducted by the Navy Clothing and Textile Research Facility (Natick, MA). Nine soldiers gave verbal ratings of "how they felt at that moment" during selected intervals of exercise and rest in the heat, and recovery out of the heat. On most SSQ items, well-being and performance capabilities were sensitive to such manipulations. Furthermore, statistically significant differences in the stressfulness of some uniform ensembles were demonstrated on some of the ESQ and SSQ items. Recovery was rapid after termination of an exercise-heat exposure.

23. A data-collection methodology, which recorded verbal responses as the data from questionnaires, was evaluated during a laboratory study of heat stress. This approach may be more convenient and safer than when questionnaires are administered using paper-and-

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pencil or on portable computers. This approach appears especially feasible when subjects are exercising, performing a primary task, or being encumbered by equipment or clothing systems. If the spectral quality of "captured speech" is adequate, voice processors can "learn" and encode verbal responses into an automated data base. In the collaborative study we chose to evaluate this methodology, the Navy Clothing and Textile Research Facility (Natick, MA) investigated the stressfulness of six configurations of the Navy Fire Fighters Ensemble (NFFE) during exercise and exposure to a hot environment. USARIEM staff members administered The Environmental Symptoms Questionnaire (ESQ) and The Subjective States Questionnaire (SSQ) during the evaluation of each NFFE configuration to measure subjective symptoms, perceived well-being, and performance capabilities. We developed the SSQ and administered it in this study for the first time. An Army psychology specialist announced each item and then paused briefly for all subjects to announce their ratings simultaneously. A subject's spoken responses were recorded on a channel of an audio tape for subsequent data reduction. Each item was analyzed independently. Some data were missing for all conditions tested. Often, subjects did not respond to an item when they were uncomfortable or preoccupied. Special care is necessary to minimize missing data when a questionnaire is administered verbally to a group, since there are fewer cues to encourage verbal responding on each item than with other administration procedures. Although surveying subjects verbally may result in missing data, these procedures maybe advantageous in some situations. Also, the NFFE configurations produced perceptible subjective states that influenced ratings of symptoms, well- being, and performance capabilities. Symptomatology was less severe and estimates of well-being and performance capabilities were greater when the NFFE was worn unzipped, coverall around the waist, or coverall buttoned up (with cooling) than when the coverall was worn buttoned up (without cooling). Some ratings among the less stressful configurations also differed significantly.

24. In a study of 45 women from Wellesley College, high caffeine consumption among users of oral contraceptives was found to be related to poorer color discrimination performance, whereas, among nonusers of oral contraceptives, it was related to better performance. Alcohol consumption (hard liquor only, not beer or wine) was found to be negatively related to color discrimination

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performance. Persons who used both oral contraceptives and who also consumed liquor were poorer color discriminators than were persons who did not use either drug.

25. A survey was conducted on the psychosocial readjustment of 164 of the estimated 10,000-40,000 Canadians who served in Vietnam with the U.S. military. Results indicate significantly greater rates of Post-Traumatic Stress Disorder (PTSD) compared with U.S. Vietnam veterans. Evidence of additional psychosocial adjustment problems such as depression, inability to handle frustration and anger, difficulty in getting along with and trusting others, and family and marital problems, as well as poor physical health, was also found. Results demonstrate that the effects of war trauma if left untreated, do not simply dissipate. Results also suggest that prolonged isolation from other Vietnam veterans, being ignored by Canadian society, being rejected as veterans by the Canadian government and the Royal Canadian Legion, feeling abandoned by the U.S. government, and lack of readjustment counseling services or Canadian mental health professionals familiar with the diagnosis or treatment of combat-related PTSD have made the readjustment of these veterans much more difficult than that of U.S. Vietnam veterans.

26. The prevalence of Post-Traumatic Stress Disorder (PTSD) was studied in a sample of 164 Canadians who served in Vietnam as members of the U.S. military. Compared to U.S. Vietnam veterans, the Canadians have significantly higher rates of acute, chronic, and delayed PTSD with the number of veterans experiencing PTSD at any time during or after service in Vietnam surpassing 65%. Data indicate the higher rates of PTSD in Canadian Vietnam veterans are likely due to three reasons: (1) lack of social support and recognition from the government of Canada and Canadian society; (2) isolation from other Vietnam veterans over the years; and (3) lack of availability of any medical or psychological readjustment counseling services from either the government of Canada or, until recently, the United States government.

27. Psychosocial adjustment was studied among 121 current and former Canadian Forces military personnel who had served in Vietnam as members of an international peacekeeping force during the period of U.S. involvement in the war. Although a fair number of respondents (10-30%) reported experiencing various kinds of

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psychosocial problems both during service in Vietnam and at the present time, the majority of these personnel did not suffer significant long-term adverse effects resulting from service in Vietnam. For a minority of personnel (6%), however, service in Vietnam proved to be very stressful, resulting in symptoms of a combat/post-combat stress reaction called Post-Traumatic Stress Disorder (PTSD). The findings confirm the traumatic nature of exposure to danger and the violent aftermath of combat in the development of PTSD, as well as the importance of social support experiences in moderating or exacerbating the symptoms of PTSD.

28. A study designed to assess the effects of a two-hour nap on cognitive performance during sustained operational conditions was conducted using 12 young, military subjects who performed operations officer duties in a simulated brigade-level command post. Subjects worked continuously over a 4.5 day period and were tested on several recurring cognitive tasks. Data from various tasks and questionnaires were analyzed to assess the effects of sleep loss on both individual and group cognitive performance. Across subjects, the results indicate significant sleep loss effects on perceived physical health, sleep quality, sleep value, and attributions of performance on mental tasks and individual and group cognitive performance. Significant individual differences in the effects of sleep loss were also noted. The findings suggest it may be advantageous to individualize the timing of naps in future studies to maximize performance.

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PUBLICATIONS:

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26. Tharion, W.J., D.J. McMenemy, A.L. Terry and T.M. Rauch. Recovery of mood changes after running an ultramarathon. Percept. Mot. Skills 71:1311-1316, 1990.

27. Tharion, W.J., E. Harman, W.J. Kraemer and T.M. Rauch. Different resistance exercise protocols on mood states. J. Appl. Sport Sci. Res. (In Press).

ABSTRACTS:

28. McMenemy, D.J., W.J. Tharion and T.M. Rauch. Effects of a sedative and non-sedative antihistamine on two evoked potentials. Supplement to Psychophysiol. 27:S50, 1990.

29. Johnson, R.F. Rifle simulator training device used for measuring soldier performance under environmental extremes. Proceedings of the American Psychological Society. 48, 1990.

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PRESENTATIONS:

36. Banderet, L.E. Considerations for selecting a portable computer to administer the UTC-PAB in the laboratory and the field. 24th Meeting DOD Human Factors Engineering Technical Group, "Designing for the User." Fort Walton Beach, FL, May 1990.

37. Jobe, J.B., B. Shukitt-Hale, L.E. Banderet and P.B. Rock. Effects of Dexamethasone on cognitive performance and mood at altitude. American Psychological Association. Boston, MA, August 1990.

38. Kobrick, J.L. Progressive effects of hypoxia on cognition and symptomatology. 38th International Congress of Aviation and Space Medicine. Paris, France, September 1990.

39. Levy, A., H.R. Lieberman, B. Shukitt-Hale, M. Silberman and T. Kadar. The effects of Nimodipine on learning in rats in relation to hippocampal morphology and Acetylcholine levels. Third International Serling Symposium on the Biology of Aging. Neve Ilan, Israel, September 1990.

40. Stretch, R.H. Overview of research and development within the Department of National Defence (Canada). Army Personnel Exchange Program Conference. Ottawa, Ontario, Canada, July 1990.

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PRESENTATIONS:

41. Tharion, W.J. B.E. Marlowe, R. Kittredge, R.W. Hoyt and A. Cymerman. Acute high altitude exposure and exercise decrease marksmanship accuracy. Military Testing Association. Orange Beach, AL, November 1990.

KEY BRIEFINGS:

42. Louis E. Banderet, Ph.D. Considerations for selecting a portable computer to administer the UTC-PAB in the laboratory and the field. 24th Meeting DOD Human Factors Engineering Technical Group, Fort Walton Beach, FL, May 1990.

43. Richard F. Johnson. Ph.D. Rifle marksmanship: Effects of combat clothing, environmental stress, and treatment drugs. Current Concepts in Environmental Medicine, US Army Research Institute of Environmental Medicine, Natick, MA, May 1990.

44. Richard F. Johnson, Ph.D. Effects of chemical protective clothing and medical countermeasures on rifle marksmanship. Brigadier R.S. Mountford, OBE, UK Director of Clothing and Textiles, US Army Research Institute of Environmental Medicine, Natick, MA, May 1990.

45. Harris R. Lieberman, Ph.D. Colonel Meng Kin Lim, Chief Medical Officer, Singapore Armed Forces, Topic: H & P Divisional Aims and Current Research, June, 1990.

46. Robert H. Stretch, Ph.D. Combat stress and research on Vietnam veterans. Senior Officers from the Canadian Forces Staff College, Toronto, Canada, March, 1990.

47. Robert H. Stretch, Ph.D. Effects of stress on decision-making in pilots. DCIEM research committee tasked by the Commander of the Canadian Air Force to investigate the role of "pilot error" in several recent CF18 fighter crashes, Downsville, Ontario, Canada, July, 1990.

48. Robert H. Stretch, Ph.D. Interview by a reporter from National Public Radio in New York City concerning research on Canadian Vietnam veterans. Interview was aired nationwide on 11 November 1990.

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KEY BRIEFINGS:

49. William J. Tharion. The use of rifle simulators in nutrition research. Brigadier General Bluxhom, British Army, Natick, MA, October, 1990.

50. William J. Tharion. The use of the Noptel ST-1000 Marksmanship Simulator in the carbohydrate load-bearing study. Major McJames, Australian Defence Force, Natick, MA, July, 1990.

51. McMenemy, D.J. and W.J. Tharion. Effects of two different antihistamines on central nervous system function. First FY90 OMPAT Meeting, Beltsville, MD, May, 1990.

SIGNIFICANT TDY:

Louis E. Banderet, Ph.D. Live Agent Chemical Training Facility, Fort McClelland, AL, May 1990.

Richard F. Johnson, Ph.D. Visit to Division of Experimental Therapeutics, to discuss possible USARIEM involvement in a mefloquine prophylaxis trial, WRAIR, 21-22 June 1990.

Richard F. Johnson, Ph.D. Visit to Division of Experimental Therapeutics, to participate in planning of detailed procedures for the conduct a mefloquine prophylaxis trial, WRAIR, 28-30 November 1990.

Richard F. Johnson, Ph.D. Annual meeting of the American Psychological Society, Dallas, TX, June 1990.

Richard F. Johnson, Ph.D. Annual meeting of the Human Factors Society, Orlando, FL, October 1990.

John L. Kobrick, Ph.D. Army Science Conference, Durham, NC, 12-15 June 1990.

John L. Kobrick, Ph.D. 38th International Congress of Aviation and Space Medicine, Paris, France, 10-13 September 1990.

John L. Kobrick, Ph.D. 32nd Annual Conference of the Military Testing Association, Orange Beach, AL, 5-9 November 1990.

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SIGNIFICANT TDY:

Harris R. Lieberman, Ph.D. Present poster at the Society of Neuroscience Annual Meeting, St. Louis, MO, October 1990.

Harris R. Lieberman, Ph.D. Present poster at the Federation of Experimental Biology and Medicine Annual Meeting, Washington, D.C., April 1990.

Harris R. Lieberman, Ph.D. Attend the American Psychological Association Annual Meeting, Boston, MA, August 1990.

Harris R. Lieberman, Ph.D. Invited Address "Nutritional Strategies to Sustain Aircrew Performance during long duration flights"; Aerospace Medical Association Annual Scientific Meeting, New Orleans, LA, May 1990.

Harris R. Lieberman, Ph.D. National Institute of Mental Health Peer-Review Panel, Washington, D.C., January, June and October 1990.

Mary Z. Mays, Ph.D. Site visit to the Pennington Biomedical Research Center, Baton Rouge, LA, 12-13 December 1990.

Mary Z. Mays, Ph.D. Attended the Defense Advisory Committee on Women in the Services (DACOWITS) Conference, Colorado Springs, CO, 20-24 October 1990.

Mary Z. Mays, Ph.D. Attended an Army High Performance Computing Workshop, US Army Medical Research and Development Command, Ft. Detrick, Frederick, MD, 26-29 November 1990.

Mary Z. Mays, Ph.D. Attended the British briefing to the US Army Chemical School on Operation Perfumed Garden, Fort McClelland, AL, 8-9 October 1990.

Barbara Shukitt-Hale. Attended the 61st Annual Meeting of the Aerospace Medical Association, New Orleans, LA, May 1990.

Barbara Shukitt-Hale. Attended the 98th Annual Convention of the American Psychological Association, Boston, MA, August 1990.

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SIGNIFICANT TDY:

Robert H. Stretch, Ph.D. Visited USARIEM to brief the Commander and his staff on recent research development at DCIEM. I spoke with Division Directors and Principal Investigators to learn about the status of research at USARIEM. I disseminated this information to the Director and various staff members at DCIEM, March 1990.

Robert H. Stretch, Ph.D. Attended the annual meeting of the Army Personnel Exchange program at the U.S. Army Attache's Office in Ottawa, Ontario. This meeting brings together all U.S. Army personnel stationed in Canada to promote an exchange of views and provide a forum for discussion of problems and matters of mutual interest, July 1990.

Robert H. Stretch, Ph.D. Visited USARIEM in my capacity as a Liaison Officer between USARIEM/USAMRDC and DCIEM. Briefings and meetings were held with the Commander and his staff, research status conveyed, and reports disseminated. Upon return to DCIEM I briefed the Director and his staff on the reorganization of USARIEM and USARIEM input to Operation Desert Shield.

SIGNIFICANT VISITORS:

BG Bloxham, Chief, British Catering Corps, October, 1990.

Dr. Tamar Kadar, Israel Institute of Biological Research, May-August, 1990.

Dr. Aharon Levy, Israel Institute of Biological Research, January-July, 1990.

Dr. Fred Owens, Professor of Psychology, Franklin and Marshall College, Lancaster, PA, October, 1990.

Ms. Tammy Ramirez, Battelle, Dayton, Ohio, February 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Louis E. Banderet, Ph.D. Massachusetts State Science Fair Judge.

Bernard J. Fine, Ph.D. USARIEM Environmental Medicine course.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Bernard J. Fine, Ph.D. Fellow, American Psychological Society.

Richard F. Johnson, Ph.D. Senior Lecturer in Psychology, Northeastern University, Boston, MA.

Richard F. Johnson, Ph.D. Reviewer, Psychosomatic Medicine.

Richard F. Johnson, Ph.D. Reviewer, Human Factors Society Annual Meeting.

Richard F. Johnson, Ph.D. Member, USARIEM Quality Assurance Committee.

Richard F. Johnson, Ph.D. Program Chair, Natick Chapter of the Sigma Xi, The Scientific Research Society.

Richard F. Johnson, Ph.D. President-Elect, Natick Chapter of Sigma Xi, The Scientific Research Society.

Harris R. Lieberman, Ph.D. Peer Review Committee, National Institute of Mental Health.

Harris R. Lieberman, Ph.D. Visiting Scientist, Department of Brain and Cognitive Science, Massachusetts Institute of Technology.

Harris R. Lieberman, Ph.D. Member, Advisory Board, Clinical Research Center, Massachusetts Institute of Technology.

Robert H. Stretch, Ph.D. Served as reviewer for the Journal of Traumatic Stress.

Robert H. Stretch, Ph.D. At the request of the Director of Social Development Services for the Canadian Forces I reviewed a service paper entitled "The Requirement for a Canadian Forces Critical Incident Stress Debriefing Team".

Robert H. Stretch, Ph.D. Interviewed by a reporter from the Montreal Gazette concerning my research on Canadian Vietnam veterans. Article appeared in major newspapers across Canada on 10 April 1990.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Robert H. Stretch, Ph.D. Selected by the Army for Long-Term Civilian Training to attend a two-year postdoctoral retraining program in Clinical Psychology at George Washington University.

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. This past year has seen significant new contributions supporting the overall medical R&D goals of sustaining the force and prevention of non-battle injuries. A series of papers has focused upon both the factors which predispose humans to heatstroke and an analysis of the factors involved in their rehabilitation to full performance capabilities and return-to-duty status. This analysis suggested that full recovery and the ability to acclimatize successfully to heat and work may not occur until 11 months post-injury in some cases. The importance of fluid homeostasis during exercise, especially the mechanisms involved in thirst and voluntary dehydration, was reviewed and analyzed in two different book chapters. These contributions, although drawing upon our own human research, dealt with new theoretical approaches to the understanding of thirst and rehydration and should provide useful insights in designing future experiments. Under the sponsorship of the American College of Sports Medicine, we chaired an important new clinical symposium entitled "Exertional Heatstroke: An International Perspective." This symposium featured six presentations and manuscripts on many aspects of exertional heatstroke such as etiology, clinical observations, pathophysiology, emergency treatment, heat intolerance and time-course of recovery. We have continued to exploit the USARIEM-developed, performance-based animal model to increase the data and knowledge base on heat tolerance, heat adaptation, and the etiology of heat illness, and to evaluate new agent prophylaxes and antidotes.

2. The endocrinological responses of salt- (NaCl) restricted adult (19.8 $\pm$ 0.6 y) male soldier test subjects were determined during heat acclimation in a simulated desert environment. After a 7 day (d) dietary stabilization (T_{amb} = 21°C) during which all subjects consumed 8 $g.d^{-1}$ of NaCl, subjects were placed on diets containing either 4 (n = 8, low salt, LS) or 8 (n = 9, control, C) $g.d^{-1}$ of NaCl. During the 10 d heat acclimation (HA) period both dietary groups walked (treadmill, 5.6 $km.h^{-1}$, 5% grade) in a simulated desert environment (41°C, 21% rh, 1.1 - 1.2 $m.sec^{-1}$ windspeed) for 16 alternating intervals of 30 min exercise and 30 min rest per day. During the dietary stabilization period levels of aldosterone (ALD), angiotensin I as estimated from plasma renin activity (PRA), and arginine-vasopressin (AVP) were all within the normal ranges except for transitory increments in ALD on d 4. We have attributed this observation to the comparative decrement in NaCl contained in

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the stabilization diet as compared to the salt content of normal garrison rations. On d 1 of HA, exercise in the heat elicited significant ($p<.05$) increments in circulating levels of both ALD and PRA with no between-group differences. By d 4 of HA, however, the striking effects of the low-salt diet were manifested in significant elevations in ALD and PRA in the LS group. By d 10 of HA, all significant effects of the low salt diet and the heat/exercise regimen had disappeared. AVP was apparently unaffected by diet or the heat/exercise protocol. These results demonstrate the importance of appropriate hormonal responses to achieve electrolyte and fluid balance during the first several days of acclimation, especially during dietary salt restriction. As the process of acclimation progressed, these hormonal responses were significantly attenuated, even while on the salt-restricted diet.

3. To assess the role of potassium (K^+) deficiency on indices of heat/exercise injury and tissue electrolyte homeostasis, adult, male rats (n=12/group, approximately 450g) were placed on a K^+-deficient diet for 14 or 28d. The 28d (vs 14d) dietary interval reduced food consumption and weight gain while water consumption was unaffected at either 14 or 28d. Mean plasma [K^+] was lowest after 28d, but plasma aldosterone concentration was minimal at 14d. Creatine phosphokinase, urea nitrogen, and glucose levels were all significantly ($p<.05$) elevated after 28d, while both creatinine and lactate dehydrogenase activity were unaffected by either dietary interval. In gastrocnemius, soleus, plantaris, and diaphragm muscles, consumption of the K^+-deficient diet elicited a temporally-related increase in tissue sodium (Na^+) with a concomitant decrease in corresponding K^+ levels. Na^+, K^+-adenosine triphosphatase (ATPase) was unaffected by K^+-depletion in these tissues. In contrast, in kidney, liver, heart, and brain, both Na^+ and K^+ levels were unaffected by dietary K^+ depletion for 28d (vs Control), and mean ATPase was increased in kidney ($p<.01$) and brain ($p<.05$). Because of the low endogenous ATPase activity and considerable intersubject variability in liver and heart, trends toward increased ATPase failed to achieve statistical significance. These results are useful in explaining the role of hypokalemia in increasing the susceptibility of individuals to rhabdomyolysis and heat injury.

4. Physostigmine (PH) alone, and pyridostigmine (PY) in

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combination with atropine and 2-PAM, have been shown to protect animals from the lethal effects of organophosphate poisoning. Acute administration of either of these carbamates results in increased heating rates (rate of rise of core temperature) and decreased endurance of exercising rats. Since we have previously reported that chronic PY administration reverses these decrements, we hypothesized the chronic administration of PH could also result in accommodation to the drug with similar attenuation of these effects. In this experiment, effects of acute (i.v., 15 min pre-run) and chronic (osmotic mini-pump) PH were compared in the following groups of rats (510-530g, male N=10/group): C (control, saline i.v.), AC-100 (acute, 100 ug/kg, 58% inhib.), CH-7 (chronic, 125 ug/hr, 7 days, 60% inhib.) and CH-14 (chronic, 125 ug/hr, 14 days, 56% inhib.). Rats were run (11 m/min, 26°C) to exhaustion. The run times and heating rates (% of control values) were AC-100- 63, 177%, AC-200- 47, 213%, CH-7- 60, 157%, and CH-14- 92, 109%. Thus, the decremental effects of acute PH administration on endurance and thermoregulation were attenuated with chronic administration.

5. Physostigmine (PH) administration in rats exercising on a treadmill (26°C, 50% rh, 11m/min, 6° incline) decreased endurance and increased the rate of rise of core temperature (heating rate). In sedentary animals PH administration resulted in a decreased core temperature that is ambient temperature (Ta)-dependent. This study was undertaken to examine the effects of Ta on the endurance and thermoregulatory decrements of PH-treated running rats. Adult male rats (510-530g) were given either 0.2ml saline (C) or 200 ug/kg physostigmine salicylate via tail vein 15 min prior to the start of running to exhaustion at 10, 15, 26, or 30°C. In both C and PH-treated groups, endurance decreased and heating rate increased with increasing Ta. At 15 and 26°C the C rats ran significantly ($p<.05$) longer and had significantly lower heating rate than the PH rats: C15 = 90$\pm$ 8 min, 0.02 $\pm$ 0.01 °C/min; C26 = 67$\pm$ 6, 0.05 $\pm$ 0.01; PH15 = 57$\pm$ 5, 0.05 $\pm$ 0.01; and PH26 = 43$\pm$ 6, 0.09 $\pm$ 0.01. At 10 and 30°C there were no significant differences between C and PH-treated rats. Apparently, 30°C is too hot for effective cooling in either group, and at 10°C both groups were able to dissipate heat despite the increased metabolic rate of the PH-treated rats. The PH-treated rat model is useful over the Ta range of 15-26°C.

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6. Nine former exertional heatstroke patients (HS) and 5 control subjects (C) were evaluated prior to and following 7 days of heat acclimation (HA; 40°C db, 24°C wb, 5.6 km/h, 5% grade, 90 min/day) to determine their physiological responses to prolonged, intermittent submaximal treadmill exercise (40°C db, 24°C wb, 30 min/h, 6h, 4.8 km/h, 5% grade). Eight HS showed normal HA responses including lower rectal temperature (Tre, $p<.02$) and heart rate (HR, $p<.05$), and small increases in plasma volume (PV) and sweat rate (SR) during the 90 min trials; these responses were similar to those seen in C. One HS, unable to complete the 90 min HA trials (Tre>39°C; HR>170bpm; exercise<70 min), was defined as heat intolerant. This HS completed only 3.8h of the 6h pre- and post-HA trials, exhibiting none of the thermoregulatory or fluid balance benefits of HA. Despite normal HA responses during the 90 min HA trials, 3 other HS showed little or no improvement following HA in Tre, HR, PV, or SR responses during the 6h exercise trials, thereby exhibiting a lack of adaptation to the heat. Under more severe environmental and/or work conditions, these 3H might exhibit heat intolerance. There were no significant differences between the remaining 5 HS and C during pre- and post-HA in heat stress indices, sweat gland function, or electrolyte and fluid balance. These results show that a lack of thermoregulatory benefit to exercise in the heat may occur in some prior exertional heatstroke patients, and that the exercise-heat tolerance test should be longer than 90 min duration.

7. The effects of hyperthermia on tissue oxygen consumption, delivery, or extraction are essentially unknown in either humans or animals. We are examining the hypothesis that redistribution of blood flow for heat dissipation may result in specific tissue hypoxia and subsequent damage. However, these measurements require sampling and evaluation across tissue beds via implanted nonocclusive catheters so as not to impede blood flow. Nonocclusive catheters are rarely used in chronically prepared animal models due to the difficult and poor success of both the surgical implantation and duration of patency. We have developed and implanted several nonocclusive catheter prototypes and doppler flow probes in the rat and rabbit. Although the small size of the rat vessels limited our ability to chronically implant the nonocclusive catheters, we have successfully implanted both venous and arterial nonocclusive catheters in several tissue beds in the non-chronic rabbit preparation. These microsurgical advances will

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now permit a thorough study of tissue blood flow during hyperthermia in a rabbit model.

8. Ventilatory patterns were measured in 14 men at different leg frequencies (f_{leg}) during treadmill exercise (TM) and cycling (CYC) after 10 days of self-paced TM to determine if entrainment of breathing frequency (f_B) to f_{leg} occurs, and if it is specific to exercise modality. Measurements of f_B, inspiratory time (T_I), and expiratory time (T_E) were obtained at f_{leg} of 50, 70, and 90 steps/min during TM and at identical f_{leg} during CYC on a second day (VO_2 range of 10-44 ml/kg/min). With progressive f_{leg} during TM, f_B increased significantly ($p<0.001$ from 20.5 ± 5.0 to 24.6 ± 5.0 to 36.6 ± 9.5 breaths (B)/min ($x\pm SD$). During CYC, f_B at 50 amd 70 RPM were similar ($x=23.9\pm2.4$ B/min) and significantly ($p<0.005$) lower than f_B at 90 RPM (28.5 ± 6.9 B/min). The average ratios of f_{leg}/f_B for each f_{leg} were similar for TM (2.59, 2.61, and 2.54) but increased with increasing f_{leg} for CYC (2.23, 2.95, and 3.70). As f_B increased, both T_I and T_E decreased progressively. Over the f_B range of 8-40 B/min, T_E was greater than T_I. With increasing f_B, T_I and T_E were similar in duration. For a given f_B, there was a predictable T_I and T_E. These relationships of T_I and T_E to f_B were similar for TM and CYC. These findings suggest that entrainment of f_B to f_{leg} can occur and that it is mode specific. The results also show that decreases in both T_I and T_E make important contributions to increases in f_B and that the relationship of T_I and T_E to f_B is independent of the mode of exercise within this VO_2 range.

9. The impact of MOPP IV configuration on fluid balance and artillery battery crew performance was evaluated during high-rate sustained firing. Three crews of 9 soldiers each participated on 3 nonconsecutive days. On one day soldiers wore the BDU and drank from canteens. Soldiers used a fluid hydraulic water delivery system when wearing MOPP IV and MOPP IV with a cooling vest (cool MOPP) on the second and third test days. All 90 rounds were fired when soldiers wore the BDU. Under similar ambient conditions, two of the three MOPP IV iterations were terminated after firing only 46 and 49 rounds, respectively. Work performance was dramatically reduced in uncooled MOPP IV; time to fire one round increased significantly by 18 sec from the first 45 rounds to the completion of all 90 rounds. During both the BDU and cool MOPP IV trials the time to fire one round was unchanged with time. Soldiers in BDU rehydrated, on average, 154% which contributed to no loss in body

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weight. Sweat rate in cooled MOPP IV was 1.4 fold higher and rehydration was less than when in BDU or cool MOPP IV, and as a consequence, body weight losses were greater.

10. We studied the role of sympathetic activity in the control of blood flow during exercise in the heat, a dual stress which simultaneously increases the demands for cutaneous and muscle blood flow. Male rats (350 g) were exercised to exhaustion in a climatic chamber (30°C) on a motor-driven treadmill (11 m/min, 6° incline). Central (c) and peripheral (p) (tail) blood pressure (BP) and body temperature (T) and plasma levels of corticosterone, epinephrine and norepinephrine were measured before, during Tc=39°C and immediately after exercise. During exercise, significant ($p<.05$) increases occurred in body temperature (Tc, 37.1 vs 40.4°C; Tp, 26.8 vs 32.9°C), cardiovascular variables (BPc, 119/101 vs 135/120 mm Hg; BPp, 115/106 vs 135/118 mm Hg), metabolic rate and plasma corticosterone. Epinephrine and norepinephrine were not significantly increased. However, at exhaustion (mean endurance = 70 min) both Tp and BPp decreased while both plasma catecholamine levels were significantly ($p<.05$) elevated. Since circulating catecholamines were significantly elevated while peripheral temperature and blood pressure declined, we concluded that a catecholamine-induced vasoconstriction of the tail contributed to sustaining cardiovascular stability. Thus, as the rat approaches hyperthermic exhaustion, the maintenance of central blood pressure and cardiac output supersedes peripheral temperature regulation.

11. Adult microswine (n=4, BW=30 kg) were used to determine fluid compartment shifts following passive dehydration. Water labelled with the stable isotope oxygen-18, NaBr, and Indocyanine Green were administered i.v. before and after passive dehydration. Comparisons of these parameters were made using a dilution technique to measure total body water (TBW), extracellular fluid volume (ECF), and plasma volume (PV). Exposure for 20-24 hrs to 31°C elicited 7% dehydration (BW loss) which produced quantitatively similar decrements ($p<.05$) in PV (8.4%, 1.39 vs 1.18 L), ECF (8.0%, 10.97 vs 10.03 L) and TBW (7.8%, 22.10 vs 19.94 L). Calculated values for interstitial and intracellular fluid also manifested reductions (8% and 12% respectively). These results demonstrate that 7% dehydration may elicit a redistribution of the body water compartments, especially intracellular water, to compensate for and protect against plasma volume loss. Further,

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the responses of the microswine are analogous to those of humans and appear directed at minimizing plasma volume loss in order to preserve cardiovascular and thermoregulatory stability.

12. During a study to determine the effect of dietary salt restriction upon an individual's ability to acclimate to heat, blood pressure (BP) was assessed at rest and during exercise. Exercise was performed on a treadmill (5° incline, 5.6km/hr) in a heat chamber (41°C, 21% rh) for 10 days, and consisted of eight (8) 30 minute exercise sessions interspersed by eight (8) 30 minute rest periods. The anticipated decreases in exercise heart rates (HR) and rectal temperatures were apparent by the 6th day of acclimation. On day 10 of heat acclimation significant decreases were noted in the systolic exercise blood pressures ($p<0.01$) and average resting blood pressures ($p<0.0006$). Mean resting BPs decreased by 11.4%, while post-acclimation resting systolic and diastolic BP's decreased 11.2% and 12.0%, respectively. While decreases in the exercise diastolic BP's were also noted, these reductions failed to achieve statistical significance. The effects of heat acclimation on blood pressure are considered plausible despite the lack of a similar control group exercised under cool conditions. Since these test subjects were physically active, young, normotensive armed service members in good physical condition (VO_2 Max > 46.5+1.1 ml/min/kg), it seems unlikely that BP or HR would be further reduced by a similar exercise regimen performed under cool conditions. Hence, these reductions may be attributable to a combination of heat-induced cutaneous vasodilation and an attenuation of sympathetic vascular tone as the fully acclimated state is achieved. These results suggest that heat acclimation may modulate mild or moderately severe essential hypertension. This non-pharmacologic reduction in BP could have significant impact in the treatment of hypertension if similar studies utilizing hypertensive subjects provided the same results.

PUBLICATIONS:

1. Armstrong, L.E., J.P. De Luca, and R.W. Hubbard. Time course of recovery and heat acclimation ability of prior exertional heatstroke patients. Med. Sci. Sports Exer. 22:36-48, 1990.

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PUBLICATIONS:

2. Armstrong, L.E., and R.W. Hubbard. Application of a model of exertional heatstroke pathophysiology to cocaine intoxication. Am. J. Emerg. Med. 8:178, 1990.

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11. Hubbard, R.W., P.C. Szlyk, and L.E. Armstrong. Influence of thirst and fluid palatability on fluid ingestion during exercise. In: Perspectives in Exercise Sciences and Sports Medicine: Fluid Homeostasis During Exercise, vol 3, C.V. Gisolfi and D.R. Lamb (Eds.). Benchmark Press, Carmel, 1990, pp 39-95.

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ABSTRACTS:

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PRESENTATIONS:

28. Armstrong, L.E. Emergency management of common heat illnesses. Physician and EMT Seminar. St. Joseph's Hospital, Lowell, MA, April, 1990.

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PRESENTATIONS:

29. Armstrong, L.E., J.P. De Luca, and R.W. Hubbard. Exertional heatstroke in soldiers: an analysis of recovery rates, predisposing factors, and residual heat intolerance. Annual Army Science Conference. Durham, NC, June, 1990.

30. Caretti, D.M., P.C. Szlyk and I.V. Sils. Effects of exercise modality on ventilation. New England Chapter of American College of Sports Medicine. Marlboro, MA, November, 1990.

31. Curtis, W.C. Diagnosis and treatment of heat injury. The Surgeon General's Working Symposium on the Prevention of Heat Illness. USARIEM, April, 1990.

32. Curtis, W.C. Clinical aspects of heat research. USARIEM's course, Current Concepts in Environmental Medicine. USARIEM, May, 1990.

33. Curtis, W.C. Diagnosis and treatment of heat illness. The Primary Flight Surgeon's Course. Fort Rucker, AL, August and October, 1990.

34. Matthew, C.B. Muscarinic and nicotinic anticholinergic drug effects in heat-stressed and exercising rats. Animal-to-Human Extrapolation Symposium. San Antonio, TX, March, 1990.

35. Matthew, W.T., and W. R. Santee. Potential heat casualty risk assessment in Southwest Asia: Weather data requirements in the spatial domain. Eleventh Annual EOSAEL/TWI Conference. Las Cruces, N.M., November, 1990.

36. Matthew, W.T. WBGT Monitoring. Working Symposium: Prevention and Treatment of Heat Injuries. Natick, MA, April 1990.

37. Szlyk, P.C. Circulatory responses to hyperthermia. Current Concepts in Environmental Medicine. USARIEM, Natick, MA., May 1990.

KEY BRIEFINGS:

38. Michael J. Durkot, Ph.D. Preventon and treatment of heat injuries. Professional Staff, Cutler Army Hospital, Ft. Devens, MA., May, 1990.

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KEY BRIEFINGS:

39. Ralph P. Francesconi, Ph.D. Prevention, diagnosis and treatment of heat injury. Adjutant General, Deputy Adjutant General, and Senior Command and Staff Officers, Wyoming National Guard, January, 1990.

40. Ralph P. Francesconi, Ph.D. COL Lim, Chief Medical Officer, Singapore Armed Forces, Research Program, Heat Research Division, USARIEM, April, 1990.

41. Patricia C. Szlyk, Ph.D. Prevention and diagnosis of heat illness. 373 General Hospital, Ft. Devens, MA., July, 1990.

42. Patricia C. Szlyk, Ph.D. WBGT: measurement and use to estimate work-rest cycles and fluid intake. 373 General Hospital, Ft. Devens, MA, July, 1990.

SIGNIFICANT VISITORS:

Stephen L. Gaffin, Ph.D., Professor & Head, Division of Biochemistry, Department of Physiology, University of Natal Medical School, Durban, Republic of South Africa, January, 1990.

MAJ Michael J. Testa and LT Rickard, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Aberdeen, Maryland, October 1990.

Batia Bleiberg, Ph.D., Albert Einstein College of Medicine, Department of Cardiology Bronx, New York, December, 1990.

SIGNIFICANT TDY:

William C. Curtis, M.D. To participate in the Annual Session of the American College of Physicians. Chicago, Ill, 26-29 March, 1990.

Roger W. Hubbard, Ph.D. To attend Shock Society Meeting and obtain information for new projects on use of hypertonic saline in treatment of heatstroke shock. Durango, CO, 8-12 June, 1990.

Roger W. Hubbard, Ph.D. To attend VIth International Conference on Sodium Pump as COR and Technical Representative. Woods Hole, MA, 5-9 September, 1990.

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SIGNIFICANT TDY:

Roger W. Hubbard, Ph.D. To attend the 4th Biennial General Meeting of the International Society for Free Radical Research (SFFR International) entitled "Oxidative Damage and Repair." Pasadena, CA, 14-20 November, 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Lawrence E. Armstrong, Ph.D. Adjunct Professor, University of Connecticut, Storrs, CT.

Lawrence E. Armstrong, Ph.D. Executive Board, New England Chapter of American College of Sports Medicine.

Michael J. Durkot, Ph.D. Executive Committee, Sigma XI, The Scientific Research Society, Natick Chapter.

Michael J. Durkot, M.S.,Ph.D. Reviewer, Aviation Space and Environmental Medicine.

Michael J. Durkot, M.S., Ph.D. Contracting Officer's Representative, USAMRDC, 1990.

Ralph P. Francesconi, Ph.D. Reviewer, Aviation Space and Envrionmental Medicine and Journal of Applied Physiology.

Ralph P. Francesconi, Ph.D. Advisor, National Academy of Sciences/National Research Council Associateship Program.

Ralph P. Francesconi, Ph.D. Contracting Officer's Representative, USAMRDC.

Ralph P. Francesconi, Ph.D. Reviewer, Army Research Office, 1990.

Roger W. Hubbard, Ph.D. Adjunct Professor of Pathology, Boston University School of Medicine, Boston, MA.

Roger W. Hubbard, Ph.D. Member, DOD-Water Resource Management Action Group (WRMAG), 1980 to present.

Roger W. Hubbard, Ph.D. Member, DOD-Steering Committee on Field Water Quality.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Roger W. Hubbard, Ph.D. Reviewer, Aviation Space and Environmental Medicine, Journal of Applied Physiology, and Journal of Wilderness Medicine.

Roger W. Hubbard, Ph.D. Reviewer, Emergency Medicine and NIH, grant proposal.

Roger W. Hubbard, Ph.D. Editorial Board, Journal of Wilderness Medicine, 1990.

Roger W. Hubbard, Ph.D. Co-chairman, Clinical Sciences - Clinical Symposium, American College of Sports Medicine, Exertional Heatstroke: An International Perspective.

Patricia C. Szlyk, Ph.D. Reviewer, Aviation Space and Environmental Medicine.

Patricia C. Szlyk, Ph.D. Science Fair Judge, Worcester Polytechnic Institute.

Patricia C. Szlyk, Ph.D. Science Fair Judge, Massachusetts State Science and Engineering Fair, MIT.

Patricia C. Szlyk, Ph.D. Special Awards Judge, US Army Laboratory Command, Research Triangle, NC.

Patricia C. Szlyk, Ph.D. Company Commander, 373 General Hospital, Boston, MA.

Patricia C. Szlyk, Ph.D. Admissions Committee, Sigma Xi Honor Society, Natick Chapter.

Patricia C. Szlyk, Ph.D. President, Sigma Xi Honor Society, Natick Chapter.

Patricia C. Szlyk, Ph.D. Delegate to National Meeting, Sigma Xi Honor Society, Natick Chapter.

MILITARY ERGONOMICS DIVISION

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1. Experiments were conducted to examine the effects of load carriage on ventilatory responses and acid-base equilibrium during walking exercise. Ten male subjects performed resting pulmonary function tests and 30 minutes of walking at 35%, 50% and 65% of maximal oxygen uptake ($\dot{V}O_2max$). Each test was performed twice, once without load carriage and once wearing a load carriage system weighting 30 kg. During the pulmonary function tests, subjects had significantly ($P<0.05$) reduced forced expiratory vital capacity, forced inspiratory volume in 1 second, and maximal voluntary ventilation with load carriage. During exercise, pulmonary ventilation and the ventilatory equivalents for O_2 and CO_2 were significantly ($P<0.05$) elevated with load carriage only at 35% $\dot{V}O_2max$, but alveolar ventilation was not significantly different at any exercise intensity. In general, blood hydrogen ion concentration, carbon dioxide partial pressure, bicarbonate concentration and lactate concentration were unaffected by load carriage during exercise. However, with load carriage, subjects perceived greater breathlessness and rated their exertion as harder. It was concluded that, while maximal ventilatory performance may be reduced, during moderate-duration submaximal exercise, load carriage does not compromise ventilatory performance or alter acid-base equilibrium. Despite physiological compensation during load carriage, subject's perception of effort and sensation of breathlessness increased.

2. This study examined the effect of added inspiratory resistance (R) to determine the relationship between respiratory sensations and hypercapnic responsiveness to exercise breathing patterns and work performance. Mild R (5 cm $H_2O \cdot L^{-1} \cdot sec^{-1}$) did not alter peak oxygen uptake, peak power output, or steady-state submaximal work duration. During progressive intensity exercise, changes in the pattern of breathing occurred with R, whereas breathing cycle timing components were relatively unchanged. During submaximal steady-state exercise, R decreased mean inspiratory flow but prolonged the duty cycle, thus maintaining minute ventilation. Exercise minute ventilation was strongly correlated to subjects' ventilatory hypercapnic responsiveness. Of the components of minute ventilation, timing and respiratory drive, the latter was correlated to hypercapnic responsiveness during both maximal intensity and submaximal exercise. Subjects' perception of R did

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affect their pattern of breathing when added inspiratory loads were present, but ventilatory responsiveness to hypercapnia was the stronger determinant of exercise hyperpnea. It may be possible to screen soldiers who are more prone to work performance decrements when wearing a CB mask. Respiratory muscle strength training programs may help alleviate the adverse respiratory sensations experienced by soldiers wearing CB masks.

3. Experiments were conducted to examine the effects of moderate hypohydration on skeletal muscle glycogen resynthesis after exhaustive exercise. On two occasions 8 males completed 2 h of intermittent cycle-ergometer exercise (4 bouts of 17 min at 60% and 3 min at 80% $\dot{V}O_2max$/10 min rest) to reduce muscle glycogen concentrations (control values of 711±41 umol·g dry wt^{-1}). During one trial, cycle exercise was followed by several hours of light upper-body exercise in the heat without fluid replacement to induce hypohydration (HY, -5% body weight); in the second trial, sufficient water was ingested during the upper-body exercise/heat exposure to maintain euhydration (EU). In both trials, 400 g of carbohydrate were ingested at the completion of exercise and followed by 15 h of rest while the desired hydration level was maintained. Muscle biopsy samples were obtained from the vastus lateralis immediately after intermittent exercise (T1) and after 15 h rest (T2). During the HY trial, the muscle water content was lower ($P<0.05$) at T1 and T2 (288±9 and 265±5 ml·100 g dry wt^{-1}; NS) as compared to EU (313±8 and 301±4 ml·100 g dry wt^{-1}; NS). Muscle glycogen concentration was not significantly different during EU and HY at T1 (200 ± 35 vs 252 ± 50 umol·g dry wt^{-1}) not at T2 (452 ± 34 vs 491 ± 35 umol·g dry wt^{-1}). These data indicate that, despite reduced water content during the first 15 h after heavy exercise, skeletal muscle glycogen resynthesis is not impaired.

4. The effect of maximal exercise on vascular fluid volume was characterized in healthy women. Four women exercised in the follicular (F, days 2-6) and luteal (L, days 19-22) phases of their menstrual cycles at an ambient temperature of 28°C with a relative humidity of 25%. After a 5 min warm-up, subjects exercised for 3 min at a power output which previously elicited $\dot{V}O_2$ peak on a cycle ergometer. Resting plasma volume (PV) was 9% (0.26±0.013L) lower in L than F ($p<0.05$) and total circulating protein (TCP) was lower

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($p<0.05$) in L (196 ± 12g) than F (214 ± 9g). After maximal exercise, PV decreased 12% (0.33±0.10*L*) in L and 19% (0.56±0.03*L*) in F to 2.36±0.23*L* and 2.39±0.18*L*, respectively ($p<0.05$). TCP decreased an average of 2 g during exercise in L and 27 g in F ($p<0.05$) to 194 ± 16g and 187 ± 13g, respectively. Peak plasma lactate occurred 2-5 min after exercise and averaged 11.8 (±2.2) $mmol \cdot L^{-1}$ in L and 10.7 (±1.7) $mmol \cdot L^{-1}$ in F. These data indicate: 1) there appears to be a lower limit to plasma volume and total circulating protein during maximal exercise in women; 2) the minimal PV seems to be dependent upon the minimal TCP; and 3) during maximal exercise in a temperate environment, the total volume of fluid shifted from the vascular volume is different during the follicular and luteal phases of the menstrual cycle, possibly showing a defense of the plasma volume by maintaining protein mass during maximal exercise in luteal-phase experiments.

5. To determine whether a change in circadian timing of core temperature (T_c) can account for the lower T_c threshold for onset of cutaneous vasodilation induced by exercise after 33 h of sleep deprivation (SD), four men were studied during two control experiments when T_c was at its peak (CON-peak) and at its nadir (CON-nadir). The men were studied again when T_c was near its peak (SD-peak). SD ranged from 40 - 56 h. A fourth experiment was done after an average recovery sleep time of 20 h when T_c was near its nadir (RECOV-nadir). The men exercised at 55% peak $\dot{V}O_2$ on a cycle ergometer (T_a=35°C; T_{dp}=12°C). Esophageal temperature and forearm blood flow (FBF, plethysmography) were measured every 0.5 min and the T_{es} threshold temperature for onset of cutaneous vasodilation during exercise (FBF threshold) was computed from linear regression equations describing the individual data and resting FBF. Although the mean FBF threshold was higher during CON-peak (~7.0°C±0.1) than CON-nadir (36.4°C±0.1), there was no difference between CON-peak and SD-peak (36.8°C±0.2) when T_c was used as a circadian marker. Likewise, there was no difference in the FBF threshold after recovery sleep between CON-nadir (36.4°C±0.2) and RECOV-nadir (36.7°C±0.2). The slope of FBF:T_{es} ($ml \cdot 100ml^{-1} \cdot min^{-1} \cdot °C^{-1}$) was greater ($p<0.05$) at CON-peak (40.0±5) than CON-nadir (23.9±5) and SD-peak (27.4±10). These data present evidence that the T_{es} threshold shift in onset of cutaneous vasodilation during SD is due to disruption of circadian timing. However, controlling circadian timing did

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not prevent the reduced slope of the FBF:T_{es} during SD, indicating that SD also impairs thermoregulation independently of its effect on circadian timing.

6. The effect of nicotinic acid (300-400 mg) ingestion on skin blood flow (SkBF) and thermal responses was studied in four subjects at rest and during moderate exercise at an ambient temperature of 84°F with a relative humidity of 30%. In one experiment, each subject took nicotinic acid and rested (NR) for 60-75 min. This experiment was compared to a control experiment with no drug (CR). In a third experiment, after skin blood flow doubled (~20 min after niacin ingestion) subjects exercised for thirty minutes (NX). This was compared to a control exercise experiment (CX). Esophageal (T_{es}) and mean skin ($\overline{T}_{sk}$) temperatures, SkBF, forearm blood flow (FBF), heart rate (HR) and mean arterial blood pressure (MAP) were measured. SkBF and FBF increased 600% in NR compared to CR ($p<0.05$). T_{es} was 0.6°C lower and $\overline{T}_{sk}$ was 0.6°C higher at peak SkBF in NR than CR ($p<0.05$). MAP was 12 Torr lower and HR was 14 $b \cdot min^{-1}$ higher at peak SkBF in NR than CR ($p<0.05$). During exercise, SkBF and FBF increased 30% and T_{es} was 0.3°C lower in NX than CX ($p<0.05$). $\overline{T}_{sk}$, HR or MAP were unchanged between NX and CX. Sweating was lower in NX than CX (6.9 vs 17.4 $g \cdot min^{-1}$, $p<0.05$). The ingestion of nicotinic acid increased skin blood flow at rest and changed core temperature, skin temperature, heart rate and arterial blood pressure accordingly. Nicotinic acid taken before exercise increased skin blood flow and sensible heat flux and decreased heat storage during exercise without significant cardiovascular changes.

7. Experiments were conducted to examine the effects of an oral 30-mg dose of pyridostigmine bromide (PYR) on thermoregulatory and physiological responses of men undergoing cold stress. Six men were immersed in cold water (20° C for up to 180 minutes on two occasions, once each 2 hours following ingestion of PYR and 2 hours following ingestion of a placebo (CON). With PYR mean (±SD) red blood cell cholinesterase inhibition was 33 (±12)% at 110 minutes post ingestion (10 minutes pre-immersion) and 30 (±) 7% at termination of exposure (X=1 minutes). Percent cholinesterase inhibition was significantly related to lead body mass ($r = 0.91$, $P<0.01$). Abdominal discomfort caused termination in 3 of 6 PYR

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experiments, but in none of the control experiments ($\bar{X}$± exposure time = 142 min). During immersion, metabolic rate, ventilatory volume, and respiratory rate increased significantly ($P<0.05$) over pre-immersion levels and metabolic rate increased with duration of immersion ($P<0.01$) in both treatments, but did not differ between conditions. PYR had no significant effect on rectal temperature, mean body temperature, thermal sensations, heart rate, plasma cortisol, or change in plasma volume. In was concluded that 30 mg of PYR does not increase an individual's susceptibility to hypothermia during cold-water immersion; however, in combination with cold-stress, PYR may result in marked abdominal cramping and limit cold tolerance.

8. Administration of pyridostigmine bromide (PYR) has been chosen by the U.S. Army as a pre-treatment for anticipated nerve agent exposure for soldiers deployed in areas with threat of Chemical Warfare exposure. We gave thirty-six healthy adults 30 mg PYR tablets and measured red blood cell cholinesterase (RBC AChE) activity after a single dose (studies HURC #306, #330, and #378) and during multiple dose (3-7 days) PYR treatment (studies HURC #377 and #403) in five separate studies. PYR was given at 0600 h, 0700 h, or 0800 h, and in multiple dose studies continued at 8-h intervals for 72-144 h. Venous blood was taken before the first PYR dose and after ingestion depending on the specific protocol. Control RBC AChE for #306 was 11.27± 1.63 $\mu mol \cdot ml^{-1} \cdot min^{-1}$; for #330, 12.35 ± 1.74 $\mu mol \cdot ml^{-1} \cdot min^{-1}$; for #377, 12.62 ± 4.00 $\mu mol \cdot ml^{-1} \cdot min^{-1}$; for #378, 13.43 ± 1.25 $\mu mol \cdot ml^{-1} \cdot min^{-1}$; and for #403, 12.55 ± 1.02 $\mu mol \cdot ml^{-1} \cdot min^{-1}$. In all five studies, mean RBC AChE inhibition ranged from -30 to -40%, 120-180 minutes after PYR was ingested. Plasma PYR concentration (#377) averaged 19.30 (±10.35) $ng \cdot ml^{-1}$ after 2 h, 36.32 (±15.91) $ng \cdot ml^{-1}$ at +26 h, and 29.65 (±10.22) $ng \cdot ml^{-1}$ at +50 h. PYR was stopped in two subjects after 50 hours in #377 as RBC AChE exceeded -60%. In #403, peak plasma PYR averaged 23.3 ± 6.7 $ng \cdot ml^{-1}$ two hours after the morning tablet and trough values averaged 10.8 ± 2.4 $ng \cdot ml^{-1}$ immediately before the morning tablet. RBC AChE inhibition averaged -10 (±1)% before the 0800 h tablet. In studies #s 377 and 403, RBC AChE activity decreased with time (up to 4-5 days in #403), suggesting altered clearance or uptake or sequestering of PYR in specific tissues.

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9. The side effects of chronic pyridostigmine bromide (PYR) administration were studied in seven male soldiers performing moderate intensity exercise in the heat. A two-week, double blind, placebo controlled, crossover design was employed in which PB was administered for 7 consecutive days (30 mg orally, t.i.d.). Four hours each day were spent in the heat (42°C, 20% rh); 2 hours rest followed by 2 hours moderate exercise (40% $\dot{V}O_2$max). Each day subjects completed four symptom questionnaires and received three focused physical examinations. Symptoms reported did not differ between treatment groups except for fewer reported headaches during PYR treatment. Just over half (57%) the subjects were able to correctly identify when they had taken PYR. PYR was associated with decreased resting diastolic blood pressure (~4 mmHG, $P<0.05$), pupil diameter (~0.5 mm, $P<0.01$) and handgrip strength (~3%, $P<0.05$), as well as a higher final rectal temperature (~0.1°C, $P<0.01$). These side effects are of little clinical significance and do not diminish the established efficacy of PYR pretreatment for protection against nerve agent poisoning. These data indicate that chronic PYR administration does not negatively impact on soldiers' ability to perform physical work over repeated days in a desert environment.

10. The use of mustard (HD, Dichloroethyl sulfide), a powerful vessicant, has been threaten by Iraq in southwest Asia. ICD 1536 (Multi Shield, Interpro, Inc., Haverhill, MA) was examined as a candidate topical protectant to determine its effectiveness in preventing penetration of a HD-simulant dye as compared to unprotected skin. The experiment was designed to answer the following questions: 1) How long was the barrier effective as judged by prevention of contact dermatitis? 2) What effect on skin protection does application of the barrier to perspiring skin have as opposed to application to dry skin? and 3) What effect does 0.1 or 0.2 mm thickness of application have on dye penetration through the topical protectant ICD 1536? ICD 1536 was applied evenly to eight different test sites on the volar surfaces of the forearms (four test sites per arm). The four remaining test sites per arm were unprotected. A dye containing iodine and methylsalicylate was used as a simulant for HD. A cellulose filter (Whatman #2) disc saturated with the dye was placed on each test area. The subjects were tested twice in each of the two environments, HOT/DRY (111°F,

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20% relative humidity, wind speed of 5 mph) and MODERATE (75°F, 50%rh, wind speed of 5 mph). A medical examination of each individual followed each experiment and the physician rated degree of contact dermatitis. Both vapor and liquid were penetrating the 0.1 mm thickness of ICD 1536 in the MODERATE environment in 5/8 subjects by 32 min of exposure, while both liquid and vapor penetration occurred in 3/8 subjects by 64 min when ICD 1536 was applied at 0.2 mm thickness. In the HOT/DRY environment, liquid penetrated the 0.1 mm thickness of ICD 1536 as early as 16 min in one subject in the HOT/DRY environment, but breakthrough occurred in 2/8 subjects by 64 min when protected, but in 7/8 subjects when unprotected. When the protectant was applied at 0.2 mm thickness in the HOT/DRY environment breakthrough occurred by 64 min in 1/8 subjects while contact dermatitis occurred in 3/8 subjects on the unprotected sites. In a 7 h experiment in the HOT/DRY environment contact dermatitis was observed in 5/8 subjects when the protectant thickness was 0.1 mm, but in only 1/8 subjects when the protectant thickness was 0.2 mm when ICD 1536 was applied after sweating occurred. Because of the early breakthrough in the HOT/DRY environment and high incidence of contact irritant dermatitis (seven of eight subjects), the 7 h experiment which was scheduled to be done in MODERATE environment was cancelled. Also, liquid penetration through ICD 1536 applied in 0.2 mm thickness occurred by 1 h in the 7 h experiment in the MODERATE environment as determined by cases of contact dermatitis. Obviously, statistical analysis of the contact dermatitis data is inappropriate, although the data do subjectively support the interpretation that the skin protectant should be applied at 0.2 mm thickness and this application provides some protection from simulant dye penetration (vapor and liquid).

11. During production of the chemical threat agent protective patient wrap (WRAP) the air permeability was reduced from 8.5-12 cfm to 4.8-6.1 cubic feet per min per square meter (cfm). The impact of reducing air permeability by that extent on respiratory air exchange across the WRAP was determined in encapsulated soldiers. A second aim of the research was to evaluate biophysical factors (thermal and water vapor resistance) which affected heat exchange during encapsulation in the WRAP to determine whether the potential heat strain generated by encapsulation was different

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between the two WRAPS. Oxygen depletion and carbon dioxide accumulation in the current WRAP was determined during a 6 h encapsulation period in a comfortable environment (T_a = 24°C; 20% = rh) for eight healthy soldiers. All subjects tolerated well the full 6 h encapsulation period. The oxygen concentration (FIO_2) decreased and carbon dioxide concentration ($FICO_2$) increased during encapsulation and both stabilized after 15 min and remained stable for the rest of the encapsulation. The average FIO_2 was 20(±0.4)% and the average $FICO_2$ was 1.1(±0.2)% during the 6 h encapsulation period. Rectal temperature increased gradually in five subjects during encapsulation while rectal temperature did not change consistently in the other three subjects. Thermal and water vapor resistance measurements showed that there were slight differences between the new and old WRAPS. This may be due to actual material differences or simply that the current WRAP was slightly thicker than the prototype WRAP. Based solely on the resulting water vapor permeation index (i_{mt}) calculated from these evaluations, the capacity for evaporative cooling should be similar and the heat strain experienced by volunteers during encapsulation should not be different between the new and old WRAPS. Consequently, the safe encapsulation time limits determined previously should not be substantially different during encapsulation in the current WRAP.

12. To determine the physiologic strain associated with wearing the improved design (Individual Protection Directorate, NATICK) Self-Contained Toxic-Environment Protective Outfit (STEPO), six heat-acclimated male soldiers walked on a treadmill (45 min each hour) and rested (15 min each hour) in a warm (27°C) and a hot (38°C) environment for up to 4 hours. STEPO was tested in its two configurations, one with the backpack rebreather-respirator and cooling vest (STEPO-R, ~30 kg), and the other tethered to a supply of breathing and cooling air (STEPO-T, ~12 kg). These systems were compared to the currently fielded Toxic Agent Protective Suit (TAP, ~8 kg). In the warm environment, endurance time was significantly longer for subjects wearing STEPO-T (~220 min) compared to STEPO-R (~110 min). TAP was not significantly different (~195 min). Only in two trials, one in STEPO-T and one in TAP, did subjects reach or approach T_{re} or HR limits. In the hot environment, endurance times were not significantly diffe ' among the three systems (STEPO-T ~80 min, STEPO-R and TAP ~55 .n), but rise in rectal temperature

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(ΔT_{re}) was greater for STEPO-R than for STEPO-T. In only four trials, one in STEPO-T and three in TAP, did subjects reach or approach T_{re} or HR limits. One half of all STEPO-R trials were terminated because of severe muscular discomfort. Further redesign of the STEPO systems is underway, and may include improved fabric, weight distribution and cooling systems, as well as water carrying capabilities. Testing of these and/or an interim STEPO system to be fielded until a final system is approved, may be done in 1991 or 1992.

13. A human biophysical environmental stress study was conducted comparing the British lightweight (Mark-IV) and current BDO chemical protective (CP) garments. The analysis included endurance time (100 min max), rate of increase in rectal temperature and net sweat loss in 7-12 subjects walking on level treadmill in the two different CP garments at 65°F/70% rh; 90°F/50% rh and 90°F/80% rh with minimal wind and without simulated solar radiation. Significant differences between the MK-IV and BDO were found for changes in Effective Temperature and sweat loss in the two 90°F environments. The rate of change in rectal temperature was significantly different in all three environments. These significant differences indicate that individuals wearing the MK-IV CP garments would incur less heat strain relative to wearing the BDO. A limited test determined that when the MK-IV was worn over lightweight battledress uniform, the heat strain experienced by subjects was not significantly different from that experienced when the BDO was worn over just underwear.

14. A cold stress study was carried out comparing various handwear items. One candidate intermediate glove combination (thin synthetic inner glove, insulated leather shell with PTFE water barrier) was found to be significantly better than the light duty (LD) glove when subjects performed a scenario consisting of 45 min of treadmill walking in ECWCS uniforms followed by 75 minutes of seated inactivity. At 0°F, the mean endurance time was 59 min versus 42 min and the rate of finger temperature drop was 0.40 versus 0.61°C·min^{-1} for the candidate glove versus the LD glove. It was also determined that other candidate gloves with a plastic moisture barrier were unacceptable for field use because the gloves

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dried extremely slowly even hung up at room temperature.

15. Current issue military handwear items were tested on an aluminum articulated thermal hand model to determine dry insulation values. Model power demand was determined at different environmental test chamber temperatures and used with the surface area of the model to calculate handwear insulation. Insulation was also calculated using the slope of the power demand versus temperature differences (chamber versus model set-point). Calculated values were compared to values measured with a sophisticated articulated copper hand model. Differences between measurements made with the two hand models were consistent and may be explained by differences in the shape of the hands and a difference in the method of calculating surface area of the new model. Methods for testing wet handwear were also investigated.

16. A study was conducted on body temperature changes during intermittent work in chemical protective clothing (BDO in MOPP 4 without the respirator or PASGT helmet). Previous studies on effects of chemical protective clothing (CPC) have generally focused on continuous work. This study investigated the impact of CPC on body core temperatures during simulated emergency-type work. We expected that esophageal temperature (T_{es}) would be a more responsive index of heat strain than rectal temperature (T_{re}). Four male subjects were studied in a 30°C, 25% rh environment. On two of four test days, work was continuous (CW) and on the other two, intermittent (IW). On one day for each type of work Ss wore t-shirts and shorts (TEE); on the other day fatigues and CPC. IW consisted of repeated 10 min cycles composed of 4 min of treadmill walking (167 $W \cdot m^{-2}$), 2 min of jogging (444 $W \cdot m^{-2}$) and 4 min of sitting (56 $W \cdot m^{-2}$). CW was the time-weighted average of the above: (183 $W \cdot m^{-2}$). T_{es} and T_{re} were measured at 15 sec intervals, averaged across Ss for each condition and compared. Tests were terminated at exhaustion or if T_{re} reached 39.5°C. While wearing TEE, for both CW and IW, all Ss completed the entire 120 min of work as expected. However, while wearing CPC mean tolerance time was reduced to 78 min for CW and 63 min for IW. T_{es} did not rise faster or achieve higher levels than T_{re}. T_{re} rose faster during IW than during CW, but was about the same at the time of exhaustion ($T_{re} \approx 39.1$°C). During work in CPC (1) tolerance is significantly less for IW than

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for CW and (2) under these conditions T_{es} does not appear to be a finer index of heat strain than T_{re}.

17. Work continues on development and refinement of biomedical models. One National Research Council Senior Research Associate working in this Division has developed a thermoregulatory simulation for heat strain prediction that incorporates new prototypes for regional blood flow and central cardiovascular stroke volume control. The focus of most mathematical simulations of human temperature regulation has been on describing heat transfer among body tissues and with the environment. Adequate mathematical representations are still needed for predicting the time course of central and peripheral cardiovascular (CV) events especially in the working soldier with various MOPP configurations. Since both CV and thermal events provide known landmarks for heat incapacitation, a simulation to predict heat strain must provide information in both areas. An accurate computerized simulation was developed that incorporates new prototypes for calculating changes in blood flow to muscle, visceral areas and skin, and changes in stroke volume, heart rate and cardiac output along with existing representations for shivering and sweat production. These analytical models, derived from published data, have been also coupled with a numerical solution of the problem of heat transport in a single cylindrical segment containing six nodes: a central blood compartment exchanging heat with viscera, muscle, fat, and vascular skin, and an avascular epidermal compartment exchanging heat with clothing and the environment. Convection coefficients are adjusted according to work mode; environmental heat transfer is modulated by clothing insulative and permeability properties. The influence of thermal and non-thermal events were adequately linked, including: (a) the combined effects of posture, activity level and skin temperature on stroke volume, (b) the (presumed) effect of "cardiovascular overload" during work in the heat on increasing muscle oxygen extraction thereby alleviating the overload, (c) incorporation of skin temperature as a modulator of the central temperature "set-point" for controlling skin blood flow and (d) the effects of increasing age (and decreasing maximal heart rate) on thermal and CV responses.

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18. Another National Research Council Senior Research Associate has developed an analytical model for extremity temperature variation prediction. Thermal and various non-thermal physical properties have been included in the model. Extremity blood perfusion effects presented in the model are also included as part of a volumetric heat generation term. Endurance times were evaluated as a function of decreases in cylinder (digit) tip temperature to a lower bound temperature of 5°C and compared with actual handwear data from various biophysics protocols. Parameters involved in the discrete form of the model equations include: environmental temperature, thermal insulation of the covered cylinder (digit), and its length and diameter. Some results of the model simulation show that the lower the temperature, the longer and smaller the diameter of the finger, all reduce the endurance times for the equivalent thermal insulation values. Further work on the development of an operational cold stress model which incorporates digital blood flow is anticipated. This output should provide valuable information both on handwear protection and extremity protection and prediction during cold stress for soldiers during rest and moderate activity levels.

19. A study incorporating the biophysical and physiological evaluation of prototype intermediate cold-wet boot systems showed that standard rubber vapor barrier boots provided increased foot protection in a cold-dry environment while subjects were at rest. Prototype leather boots incorporating waterproof/breathable protective membranes allowed significant moisture ingression after a protracted soak in shallow water. This soaking contributed to minor impairments while performing intermittent exercise in a moderately cold-wet environment.

20. An additional study covering the biophysical evaluation of candidate U.S. Navy cold weather safety boots (using the automated copper foot model) showed that boots lined with a waterproof /breathable, polyester-ether membrane (Sympatex) had significantly smaller reductions in overall thermal insulation resulting from an 18 hr immersion in 5 cm of water when compared to boots with polytetrafluoroethylene (PTFE) membranes or without any membrane at all.

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21. Biophysical evaluations were done using the Hohenstein plate (which simulates skin "sweating" vapor flow) on samples of chemical protective (CP) materials. Items tested included samples from an originally tested CP patient wrap and one from a new CP patient wrap with slightly dissimilar $\dot{V}o/\dot{V}co_2$ diffusion rates for anticipated use in Saudi Arabia. The new prototype showed no significant differences in thermal resistance, water vapor resistance and moisture permeability indices indicating similar capacity for evaporative cooling in the new and previously tested patient wraps. A concurrent human physiological evaluation of the two patient wraps also showed no significant differences in subject thermal comfort/strain during a six hour encapsulation at moderate air temperatures.

22. Thermal manikin evaluations of chemically sorptive underwear (one-piece and two-piece) were completed. The evaluations included the items alone and underneath the Aircrew Uniform Integrated Battlefield shell (AUIB), BDO, aircrew BDU, Combat Vehicle Crewman (CVC), CVC and Suit Chemical Avoidance Liquid Protective (SCALP), CVC alone and SCALP alone. No differences in heat and vapor transfer properties were apparent for the one and two-piece underwear. The addition of chemical overgarments also showed little differences in heat transfer properties. The overgarments evaluated maintained proportional ranking according to dry insulation (clo value) and evaporative potential (i_m/clo) for total heat flux through the clothing system. Relative ranking of the garments based on the criterion in which the highest i_m/clo potential is ranked as '1' having the least likely possibility to cause heat strain gave the following rankings: (1) sorptive underwear one and two-piece used in the "open" configuration, (2) the latter garment in a "closed" configuration, (3) CVC (closed), (4) aircrew BDU, (5) AUIB closed, (6) BDO (closed), (7) SCALP (closed), and (8) SCALP+CVC (closed). Such ranking criterion, although precluded by wind and activity levels, serves in judging heat strain model prediction properties of the uniform systems.

23. During the current year successful completion of Version 3.0 of the USARIEM Heat Strain Model was done which now includes an improved expanded clothing menu and algorithms for formulation of the WBGT from basic temperature, wind speed, and relative humidity.

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As a result, input into seven taskings crucial to Desert Shield operations was possible as well as the entire model formulations that went into development of a guide to "Sustaining Health and Performance in the Desert" and TB MED-507.

24. Successful reprogramming, in Microsoft C, by our Division's Internist was done to the original USARIEM empirical heat strain model. This new version has incorporated windows and pop-up menus to facilitate user input. It also generates presentation quality graphical outputs to the screen. Numeric output is saved onto disk files. The program, when run from a batch file, also incorporates a pop-up terminate and stay (TSR) medical advisor. This TSR advisor option allows the user to arbitrarily interrupt the main program to read synopses of Army and standard medical doctrine and recommendations for heat stress environments. Much additional work needs to be done to refine and verify the program and run it against other thermal models. The next major goal is to incorporate a cold stress module based, perhaps, on Shitzer's model. The long term intent is to create a portable PC-based biophysics/environmental medicine work station for field medical officers.

25. A comparison of the heat flow measuring properties from four different types of heat flux transducers was accomplished. This involved design and incorporation of calibration procedure using the skin model (Hohenstein) system. It was found that factory calibration values often are off by as much as ±10 per cent. With the newly designed technique for calibration, pre-experimental calibration can be accomplished readily. Several Division protocols used this procedure to obtain calibration constants for the heat flow transducers used to characterize sensible heat loss following sunburn and water immersion experiments.

26. Design of a USARIEM medical database system was also accomplished during the current year. The principal purpose is to improve the tracking of test subject medical problems. It will improve the ability of USARIEM and Natick RD&E Center clinic physicians to monitor the medical and clearance status of the test subjects on a day to day basis as well as providing a basis for longer term epidemiologic reports. The many elements of

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information pertaining to the demographics, medical status, and risk exposure of test subjects along with summaries of studies will be coalesced in one central location (Oracle-based database files in the USARIEM VAX). The database has been designed and implemented so that the medical portion is accessible only by the physicians.

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6. Endrusick, T L., W.R. Santee, L.A. Blanchard and R.R. Gonzalez. Effectiveness of waterproof, breathable handwear in a cold environmenmt. In: Proceedings of the International Conference on Environmental Ergonomics-IV, Austin, TX, 1990, pp. 104-105.

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8. Kolka, M.A. and B.S. Cadarette. Heat exchange after cholinolytic and oxime therapy in protective clothing. Mil. Med. 155:390-394, 1990.

9. Levine, L., M.D. Quigley, B.S. Cadarette, M.N. Sawka and K.B. Pandolf. Physiologic strain associated with wearing toxic-environment protective systems during exercise in the heat. In: Advances in Industrial Ergonomics and Safety Research. B. Das (Ed.). Taylor & Francis, Ltd., London, 1990, pp. 897-904.

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11. Nielsen, R. and T.L. Endrusick. Thermoregulatory responses to intermittent exercise are influenced by knit structure of underwear. Eur. J. Appl. Physiol. 60:15-25, 1990.

12. Nielsen, R. and T.L. Endrusick. Sensations of temperature and humidity during alternative work/rest and the influence of underwear knit structure. Ergonomics 33:221-234, 1990.

13. Nielsen, R. and T.L. Endrusick. Localized temperatures and water vapor pressures within the clothing of working man in the cold. In: Proceedings of International Conference on Environmental Ergonomics - IV, Austin, TX, 1990, pp. 82-83.

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15. Pandolf, K.B. Heat tolerance and aging with application to industrial jobs. In: Advances in Industrial Ergonomics and Safety II. B. Das (Ed.). Taylor & Francis Ltd, London, 1990, pp. 19-26.

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19. Santee, W.R. and S.KW. Chang. Comparison of methods for determination of handwear with a biophysical model. In: Proceedings of International Conference on Environmental Ergonomics - IV, Austin, TX, 1990, pp. 102-103.

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21. Santee, W.R., J.M. McGrath, T.L. Endrusick and L.P. Wells. Evaluation of two cold weather gloves during active non-contact and passive contact activities. In: Proceedings of International Conference on Environmental Ergonomics - IV, Austin, TX, 1990, pp. 86-87.

22. Sawka, M.N. and P.D. Neufer. Interaction of water bioavailability, thermoregulation and exercise performance. In: Fluid Replacement and Heat Stress. Food and Nutrition Board, Institute of Medicine, National Academy of Sciences, Washington, D.C., 1990, VII, pp. 1-20.

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PRESENTATIONS:

47. William R. Santee, Ph.D. Comparison of light duty gloves with natural and synthetic materials under wet and dry conditions. International Ergonomics and Safety Conference, Montreal, Canada, June 1990.

48. William R. Santee, Ph.D. Comparison of methods for determination of handwear insulation with a biophysical model. International Conference on Environmental Ergonomics-IV (ICEE), Austin, TX, October 1990.

49. Sawka, M.N. Hydration effects on temperature regulation and human performance. The University of Texas, Austin, TX, February 1990.

50. Sawka, M.N. Hydration effects on temperature regulation and human performance. University of Houston, Houston, TX, February 1990.

51. Sawka, M.N. Importance of blood tonicity and volume on thermoregulation in humans. Singular and Interactive Effects on Blood Tonicity and Volume in Dehydration Symposium. American Physiological Society Symposium, Federation of American Societies for Experimental Biology Meeting, Washington, DC, April 1990.

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PRESENTATIONS:

52. Sawka, M.N. Hydration, exercise and temperature regulation. Symposium on Thermal Physiology. Eastern Temperature Regulation Group Annual Meeting. The Pennsylvania State University, Milton S. Hershey Medical Center, Hershey, PA, May 1990.

53. Sawka, M.N. Physiology and temperature regulation during upper body exercise. University of Connecticut, Storrs, CT, October 1990.

54. Sawka, M.N. Cardiovascular adjustments to acute and chronic aerobic exercise. Massachusetts General Hospital, Boston, MA, November 1990.

55. Young, A.J. Thermal and nonthermal effects of water immersion on physiological responses to rest and exercise. University of Connecticut, Storrs, CT, April 1990.

56. Young, A.J. Effects of aging on human thermoregulation in cold environments. Invited presentation in the symposium on Aging and Industrial Performance, held at the Annual Industrial Ergonomics and Safety Conference, Montreal, Quebec, Canada, June 1990.

57. Young, A.J. Structural and functional aspects of human skeletal muscle physiology. Massachusetts General Hospital, Boston, MA, September 1990.

58. Young, A.J. Effects of adaptation to extreme environments on metabolism of exercising humans. Invited presentation at the Founding Symposium of the International Society for Adaptive Medicine, Freiburg, Germany, September 1990.

59. Young, A.J. Cardiovascular and thermal effects of immersion. Invited presentation in the symposium on Research and Clinical Applications of Swimming, annual meeting of the New England Chapter of the American College of Sports Medicine, Marlborough, MA, November 1990.

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KEY BRIEFINGS:

60. Richard R. Gonzalez, Ph.D. Problems involved in modeling cold stress and clothing heat transfer properties: effects of extremities. NATO RSG-20, Panel VIII Meeting, Brussels, Belgium, February 1990.

61. Margaret A. Kolka, Ph.D. Review and analysis of medical chemical defense program. Natick, MA, February 1990.

62. Margaret A. Kolka, Ph.D. Brief MG Russell, Commanding General USAMRDC "Acute atropine or pyridostigmine administration on human thermoregulation", Natick, MA, April 1990.

63. Margaret A. Kolka, Ph.D. Brief BG Prather, Commanding General TROSCOM "Chronic pyridostigmine administration during exposure to desert environments", Natick, MA, August 1990.

64. Margaret A. Kolka, Ph.D. Provided input to USAMMDA and USARICD for In-Process-Review of pyridostigmine bromide program. Ft. Detrick, Frederick, MD, August 1990.

65. Margaret A. Kolka, Ph.D. Milestone 1B In-Process Review: Nerve Agent Pretreatment, Pyridostigmine (NAPP). USAMMDA, Ft. Detrick, Frederick, MD, December 1990.

66. Kent B. Pandolf, Ph.D. Environmental physical stress: high altitude, cold and heat; Advanced Course at Army War College, Carlisle Barracks, PA, March 1990.

67. Kent B. Pandolf, Ph.D. Heat strain models: past, present & future; Heat Injuries Working Symposium, U.S. Army Research Institute of Environmental Medicine, Natick, MA, April 1990.

68. William R. Santee, Ph.D. Comparisons of the British Mark IV and Battle Dress Overgarment to environmental heat stress. Joint Working Group, TRADOC, Fort Monroe, VA, February, 1990.

69. Michael N. Sawka, Ph.D. Environmental medicine research applications to the manned space program. Johnson Space Center, Houston, TX, February 1990.

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KEY BRIEFINGS:

70. Michael N. Sawka, Ph.D. Prediction modeling of thermoregulatory responses to military tasks. U.S. Army Chemical School, Fort McClellan, AL, March 1990.

71. Michael N. Sawka, Ph.D. Hypohydration effects on thermoregulation and work performance. Navy Bureau of Medicine and Surgery Scientific Meeting, San Diego, CA, November 1990.

72. Michael N. Sawka, Ph.D. Effects of pyridostigmine on soldiers' thermoregulatory responses to exercise and thermal strain-review of research program; U.S. Army Materiel Development Activity, Frederick, MD, November 1990.

SIGNIFICANT TDY:

Richard R. Gonzalez, Ph.D. and Mr. Clement A. Leveil. To participate in an information meeting (Dusty Agent Working Group), Pentagon, Washington, DC, 15 August 1990.

Richard R. Gonzalez, Ph.D. To chair a session on Measurement Techniques and participate in the International Conference on Environmental Ergonomics-IV (ICEE), Austin, TX, 30 September-5 October 1990.

Matthew J. Reardon, MAJ, MC. To attend Emergency Medicine & Acute Care/Series 3 & Emergency Medicine & Acute Care/Series 4, San Francisco, CA, March and December 1990.

William R. Santee, Ph.D. To serve as USARIEM Representative in a TRADOC/Joint Working Group (JWG) on Lightweight CB Protective Suits, Fort Monroe, VA, 1 February 1990.

William R. Santee, Ph.D. To participate in the 75th Anniversary Meeting of the Ecological Society covering topics on remote sensing devices, Snowbird, UT, 2 August 1990.

William R. Santee, Ph.D. To participate in a Lightweight Chemical Protective Working Group, Pentagon, Washington D.C., 16 November 1990.

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SIGNIFICANT TDY:

Michael N. Sawka, Ph.D. To participate in Military Man in Space Meeting, Houston, TX, 25 February-1 March 1990.

Michael N. Sawka, Ph.D. To attend P^2NBC^2 meeting and provide briefing on thermoregulatory modeling, FT McClellan, AL, 6-7 March 1990.

Michael N. Sawka, Ph.D. To attend and present briefing at Navy Hyperhydration Meeting, San Diego, CA, 5-6 November 1990.

Lou A. Stephenson, Ph.D. To participate in a meeting to draft the instruction sheet for field users to be included in the packaging of the threat agent protective patient wrap, U. S. Army Biomedical Research and Development Laboratory, Fort Detrick, MD, 20 December 1990.

Andrew J. Young. To participate in the 30th meeting of the Air Standardization Coordinating Committee's Working Party 61, DCIEM, Downsview, Canada, 5-10 November 1990.

SIGNIFICANT VISITORS:

Drs. Ulf Berg, Ingvar Holmer and Mr. Hakkon Nilsson, Swedish National Institute of Occupational Health, Solna, Sweden.

Mr. Christopher Gooderson, Applied Physiology Research Establishment, Farnborough, United Kingdom.

Mr. Todd Miner, Coordinator, Alaska Wilderness Studies, University of Alaska, Anchorage, Alaska.

Dr. Ruth Nielsen and Ms. M. Bakkevig, Laboratory of Heating and Air Conditioning, Technical University of Denmark, Lyngby, Denmark.

Capt. Surgeon General Leif Vanggaard, Royal Danish Navy, Copenhagen, Denmark.

MILITARY ERGONOMICS DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Richard R. Gonzalez, Ph.D. Standards Preparation Committee (SPC 55-81R) Member, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

Richard R. Gonzalez, Ph.D. USA Technical Advisory Group to the International Standards Organization (ISO) Committee 159, "Ergonomics of the Physical Environment". Development and evaluation of a series of standard practices on the assessment of thermal stress and strain.

Richard R. Gonzalez, Ph.D. Member NATO PANEL VIII, Research Study Group 20: Human Modelling of Cold Exposure.

Richard R. Gonzalez, Ph.D. Adjunct Professor, Environmental Science and Physiology, Harvard School of Public Health, Harvard Medical School, Boston, MA.

Margaret A. Kolka, Ph.D. Member, U.AS. Army Medical Research and Development Command Steering Committee for Multichambered Autoinjector, Fort Detrick, Frederick, MD.

Kent B. Pandolf, Ph.D. Adjunct Professor of Health Sciences, Department of Health Sciences, Sargent College of Allied Health Professions, Boston University, Boston, MA.

Kent B. Pandolf, Ph.D. Adjunct Clinical Professor of Sports Biology, Springfield College, Springfield, MA.

Kent B. Pandolf, Ph.D. Editor, Exercise and Sport Sciences Reviews.

Kent B. Pandolf, Ph.D. Editorial Board Member, Ergonomics.

Kent B. Pandolf, Ph.D. Member, Publications Committee, American College of Sports Medicine, Indianapolis, IN.

Kent B. Pandolf, Ph.D. Counselor, Steering Committee, Environmental and Exercise Physiology Section, American Physiological Society, Bethesda, MD.

MILITARY ERGONOMICS DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Kent B. Pandolf, Ph.D. Vice-President, International Society for Adaptive Medicine, Freiburg, FRG.

Michael N. Sawka, Ph.D. Adjunct Associate Professor, Department of Physical Therapy, Institute of Health Professions, Massachusetts General Hospital, Boston, MA.

Michael N. Sawka, Ph.D. Member, Nuclear Biological Chemical Protective Equipment Subgroup, Chemical Defense Technical Cooperation Program.

Michael N. Sawka, Ph.D. Member, Project Review Committee, American College of Sports Medicine, Indianapolis, IN.

Michael N. Sawka, Ph.D. Member, Position Statement Committee on Fluid Replacement During Exercise, American College of Sports Medicine, Indianapolis, IN.

Michael N. Sawka, Ph.D. Advisory Board, Center of Excellence for Cardiovascular Studies, Graduate Hospital System, Philadelphia, PA.

C. Bruce Wenger, M.D., Ph.D. Member, Subcommittee C95.1-IV, Working Group 11 (Metabolism/Thermoregulation), American National Standards Institute, New York, NY.

Andrew J. Young, Ph.D. Member, Editorial Board, Medicine and Science in Sports and Exercise, Indianapolis, IN.

Andrew J. Young, Ph.D. Chairman, Public Information Committee, American College of Sports Medicine, Indianapolis, IN.

Andrew J. Young, Ph.D. Member, Publications Committee, American College of Sports Medicine, Indianapolis, IN.

MILITARY NUTRITION DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. USARIEM is the lead laboratory for medical testing of the capability of the Army Field Feeding System (AFFS) to deliver adequate nutrition to soldiers operating in environmental extremes. The annual program of Ration Sustainment Testing was implemented in 1989 at the direction of the Deputy Under Secretary of the Army (DUSA-OR). In 1990, USARIEM conducted field feeding tests of the AFFS in an arctic and in a high altitude environment. Phase II of a three-phase nutritional evaluation of the AFFS in a cold environment was conducted at FT Greely, Alaska in February 1990. (Phase I was conducted in 1989; phase III will be conducted in 1991.)

The Meal, Ready-to-Eat (MRE) and the Ration, Cold Weather (RCW) (Marine Corps Arctic Ration) are currently the two individual combat rations available for general use in a cold environment. In the field studies conducted to date, the RCW has proven to be equal or superior to the MRE in terms of acceptability, convenience, and operational characteristics; however, neither has demonstrated any clear advantage in meeting energy requirements, preventing body weight loss, or maintaining hydration status. In the phase I test conducted in Alaska in 1989, it was shown that adding a Supplemental Pack (containing popular food items most commonly taken into the field by soldiers) to the MRE, increased energy intake from 2830 kcal to 3553 kcal. It was concluded that in a cold environment, three MREs and one Supplemental Pack would be a viable alternative to the normal issue of four MREs.

The objectives of this phase II study were to compare consumption of the Meal, Ready-to-Eat VIII with a Supplemental Pack (MRE VIII +) against consumption of the RCW and to assess whether either, or both, would provide the nutritional support required by military personnel working in an arctic environment.

The study was conducted concurrently using two Companies of Light Infantry soldiers from the Sixth Infantry Division (L) that were engaged in a field training exercise at Fort Greely, Alaska, in temperatures as low as -55°F. Prior to deployment, initial body weights and heights were measured and a urine sample (for estimation of hydration status) was taken from all subjects. On a smaller subsample, activity monitors were attached and a blood sample taken. Once in the field, additional or privately purchased food was not permitted, and one Company was fed three MRE VIIIs and one Supplemental Pack (4604 kcal) daily and the other Company, one

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

RCW (4568 kcal) daily. Subjects recorded their food and water intake and food acceptability in a 24-hour Dietary Log. These entries were verified daily when subjects were met to collect their urine samples and food record cards. Postmeasurements taken on the last morning of the study included body weights and a urine sample from all subjects and a blood sample from those who had provided a sample at the beginning of the study. A questionnaire was also administered to ascertain the subjects' opinions on various aspects of the ration.

Activity levels of both groups over the 8 days of the study were similar. Mean daily energy intakes were significantly different: 2729 kcal for the MRE VIII + group and 2943 kcal for the RCW group. These failed to meet the Military Recommended Dietary Allowance (MRDA) of 4500 kcal per day for cold weather operations. Mean body weight losses were significant but not different between groups: 2.8 lb (1.6%) for the MRE VIII + group and 2.9 lb (1.7%) for the RCW group. Part of the low nutrient intake can be attributed to the very low food consumption on days 1 and 2. When these days are excluded, mean intakes were no longer significantly different, being 2963 kcal for the MRE VIII + group and 2948 kcal for the RCW group.

The energy intake of MRE VIII + group (2963 kcal) was considerably less than in last year's study when intake for a similar group was 3518 kcal. This was probably due to differences in energy expenditure. Energy expenditure calculated from food intake and weight loss was estimated as 3998 kcal for this year's study and 4603 kcal for last year's study. Nutrient intakes for both groups were generally adequate; however, intakes of four micronutrients and calcium in the RCW group failed to meet the MRDA.

In general, the MRE was more favorably received than the RCW, with the Supplemental Pack being extremely popular. No pattern could be seen indicating that acceptance changed over time, partly because of the comparatively short length (10 days) of the study.

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Fluid intake was generally good: the mean daily water intake was 3.4 L/day for the MRE VIII + group and 3.7 L/day for the RCW group. The mean urine specific gravities were 1.020 for the MRE VIII + group and 1.021 for the RCW group indicating adequate hydration.

The results of this study indicate that both rations were similar in terms of their nutritional intake and ability to maintain hydration status, but neither group consumed sufficient calories to meet the MRDAs and maintain body weight. A decision on which ration to use for cold weather operations must, therefore, depend on the logistical and tactical scenarios.

2. The second AFFS evaluation was conducted with a battalion-sized task force of the 937th Engineer Group from Fort Riley, Kansas, deployed to Potosi, Bolivia, in July of 1990 to build an airfield and conduct civic and humanitarian action at the request of the Bolivian Government. The base camp and the construction site were located on the Andean altiplano near Potosi, Bolivia, and ranged in elevation from 11,500-13,300 feet. Soldiers were fed a ration cycle of B/MRE/B from a field mess. The rations were supplemented with fresh fruit and bread. A subsample of 84 test subjects were studied prior to, during, and after deployment to high altitude. Food and fluid intakes were recorded for 15 consecutive days. Food acceptability was assessed with a 9-point hedonic scale. Daily urine samples (for estimation of hydration status) and body weights were recorded for all test subjects. Twenty-four hour urine collections were made on a subsample (N=30) for the first and last two days of the study. These 24-hour urine samples were analyzed to permit the calculation of nitrogen balances. Caloric intake decreased for the first 3 days at altitude, stabilized for 6 days, and then decreased slightly towards day 15. Nitrogen balances were positive both in the beginning and end of the first two weeks at altitude; however, they were significantly more positive at the end than at the beginning of altitude exposure. Mean daily energy intakes were approximately 2000 kcal/day resulting in a loss of 3.7 lbs of body weight over this time period. Ration acceptability was generally good and did not decline over time. The results of this study indicated that there was a predictable loss of appetite in soldiers when rapidly deployed to altitude. Appetite improved with time but remained blunted resulting in a moderate loss of body weight. The soldiers

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did maintain a good hydration status suggesting that the thirst response was adequate to overcome the arid environment and altitude-induced diuresis. Carbohydrate supplementation via the beverage component of the diet would be an effective method of increasing energy and carbohydrate intake for military high altitude operations.

3. Previous studies have suggested that perception of effort during endurance exercise can be altered by dietary carbohydrate (CHO) content. The effects of CHO supplementation on perceived exertion were studied during prolonged, heavy load-carriage (L-C) exercise in six male soldiers fed for 5 days, in random order, isocaloric diets high (H, 550g/day), moderate (M, 400g/day), or low (L, 250g/day) in CHO content. During each of the first 3 days, subjects exercised by carrying a 45 kg load for 3-4 hours. On the fifth day they performed a 2-hour treadmill L-C test (4.86 km/hr, 5% grade, 45 kg load). Energy cost (VO_2) and differentiated ratings of perceived exertion (RPEs) were determined at the end of the first 10 minutes and every 20 minutes thereafter. Three RPEs were measured: local (feelings of exertion in leg muscles and joints), central (ventilatory and circulatory), and overall. VO_2 increased significantly over time for all conditions, but no differences occurred among diets. Final VO_2 averaged 62% of VO_2max. RPEs also increased ($p<.001$) over time for each condition, but after 30 minutes of exercise, local RPE (but not central or overall) was significantly higher ($p<.01$) in subjects fed the L CHO diet compared to the M or H CHO diets. No differences in RPEs were seen between the M and H CHO diets. It is concluded that subjects on low CHO diets perceive heavy L-C exercise as more physically demanding, due possibly to lower muscle glycogen levels.

4. In response to a request by The Office of the Surgeon General and the Commandant, U.S.Marine Corps, the Military Nutrition Division is developing and pilot testing a sports nutrition program for training environments that demand a high level of physical performance. The project consists of two major components: (1) nutrition education with an emphasis on sports nutrition principles and (2) nutritional menu standards for menu

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planning and su gested menu modifications with recipe ideas for a "training table."

A dietary survey was conducted at the Marine Corps Combat Development Command (MCCDC), Quantico, Virginia, in August 1990. This field study collected baseline data to be used for the planning and evaluation of the performance nutrition intervention project. The study population consisted of 124 senior OCS students during their final 2 weeks of a 10-week training cycle. The data collection effort consisted of (1) development and administration of a nutrition knowledge questionnaire, (2) administration of a food frequency questionnaire to assess usual dietary practices, (3) collection of 5-day food records to assess dietary intakes at OCS, (4) urinalysis to assess hydration status, (5) measurement of body weights at the end of the training cycle to be compared to OCS-obtained initial weights to determine weight changes, and (6) extraction of physical fitness test scores and meteorological data from school records.

Data reduction and analyses are in progress. All recipes for food items served at OCS during the study period and all recipes denoted in the MCCDC Master Menu have been coded and analyzed for nutrient content. A computerized menu analysis will be performed pending completion of computer software. Menu revisions to reduce fat and increase carbohydrates along with appropriate nutrition education training aids modeled after similar sports nutrition instruments will be implemented and evaluated for their effectiveness in achieving nutrient intakes recommended for an active "training table" feeding program for soldiers and marines engaged in activities requiring a high level of physical performance.

5. During the spring of 1990, a study was conducted at the U.S. Military Academy (USMA) in West Point, New York. This study was requested by the Office of Institutional Research at the Academy to determine the nutritional health of the cadets as a result of a new policy to offer the cadets the option of eating their weekday evening meal (in addition to their five weekend meals) away from the dining hall. A survey was conducted over the electronic mail network (E-mail) to establish a pool of volunteers for the study. From this pool of male and female cadets, USMA established three

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groups of males and three groups of females representing cadets who ate most (4-5) of the evening weekday meals in the dining hall, those who ate a minimal (0-1) number of meals in the dining hall, and those who ate an intermediate (2-3) number in the dining hall. A total of 117 males and 86 females participated in the study, and each one kept a food record over a continuous 7-day period. The majority of male and all female subjects were then interviewed by a dietitian to further characterize the data collected by each cadet. In addition, each cadet completed a questionnaire of background and medical data. Complimentary data on the body composition, blood lipids, and iron status for each cadet were collected by the Exercise Physiology Division. Comparing the actual data collected to the projections from the E-mail survey, the cadets overestimated the number of meals they consume in the cadet mess. In addition to the required meals at West Point, the subject cadets consumed food from over 200 different establishments including fast food, take-out meals, formal restaurants, and convenience stores. Nutrient information is being compiled for all these sources of food.

6. The Military Nutrition Division along with the Heat Research and Health and Performance Divisions conducted a metabolic study designed to determine if the sodium content of operational rations can be reduced without jeopardizing the health of soldiers who might be rapidly deployed to a hot environment prior to heat acclimation. This study was initiated at the request of the Vice Chief of Staff of the Army and the DCSLOG. The Military Nutrition Division of USARIEM and the Food Engineering Directorate of Natick Laboratories designed diets based upon the MRE entrees that contained either 4 or 8g of Nacl. These diets correspond to a "low" and a "normal" sodium intake. Two groups of volunteers N=9 and 8, respectively, were placed on a 7-day dietary stabilization period (no heat exposure) and 10 days of heat acclimation ($8h/day^{-1}$) at 41°C, 20% rh while walking at 5.6 $km.h^{-1}$ for 30 min/h^{-1}). Samples from food, sweat, feces, and urine are in the process of analysis for sodium to permit calculation of sodium balance. The results from the physiological adaptations to the heat exposure can be found in the section of this report by the Heat Research Division and the results on symptoms experienced during heat acclimation can be found in the section of this report by the Health and Performance Division. It was concluded that consumption of the low sodium (4g Nacl) diet resulted in physiological responses similar to the normal sodium diet (8g Nacl) during heat acclimation. There

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were some differences in fluid-electrolyte homeostasis and in early symptomology at the low level although these differences were not severe. The results of this study indicate that heat acclimation can occur at relatively low levels of Nacl intakes. These results will assist in the ultimate determination of whether or not to lower the sodium content of military field rations.

PUBLICATIONS:

1. Edwards, J.S.A., D.E. Roberts, J. Edinberg, and T.E. Jones. The meal, ready-to-eat consumed in a cold environment. USARIEM Technical Report No. T9-90, 1990.

2. Edwards, J.S.A., D.E. Roberts, S.H. Mutter, and R.J. Moore. Comparison of the meal, ready-to-eat VIII with supplemental pack and the ration, cold weather consumed in an arctic environment. USARIEM Technical Report No. T21-90, 1990.

3. Edwards, J.S.A. and D.E. Roberts. The influence of a high calorie supplement on the consumption of the meal, ready-to-eat in a cold environment. Mil. Med. (In Press).

4. Edwards, J.S.A., D.E. Roberts, and S.H. Mutter. Rations for use in a cold environment. Journal of Wilderness Medicine. (In Press).

5. Glenn, J.F. R.E. Burr, R.W. Hubbard, M.Z. Mays, R.J. Moore, B.H. Jones, and G.P. Krueger (Eds.). Sustaining health and performance in the desert: Environmental medicine guidance for operations in southwest asia. USARIEM Technical Note No. 91-1, 1990.

6. Jones, T.E., R.W. Hoyt, C.J. Baker, P.S. Walczak, R.A. Kluter, C.P. Shaw, D. Schilling, and E.W. Askew. Voluntary consumption of a liquid carbohydrate supplement by special operations forces during a high altitude cold weather field training exercise. USARIEM Technical Report No. T20-90, 1990.

7. Jones, T.E. Underwater Construction Team Arctic Operations Manual, Food and Nutrition Section. (In Press).

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PUBLICATIONS:

8. Rose, M.S., J. Finn, C. Radovsky, M. Benson, K. Samonds, D. Poe, M. Sutherland, W. Wisnaskas, C. Baker, D. Sherman, and E.W. Askew. Computerized analysis of nutrients (CAN) system. USARIEM Technical Report No. T2-90, 1990.

9. Salter, C.A., D. Sherman, S.O. Adams, and K.L. Rock. Feeding concept, military vs. civilian system. U.S. Army Natick RD&E Center Technical Report No. Natick TR-91 011, 1990.

ABSTRACTS:

10. Askew, E.W., M.S. Rose, G.M. Hashiro, P.B. Rock, and C.S. Fulco. Carnitine excretion following exhaustive exercise at sea level and high altitude. FASEB J. 4(3):A801, 1990.

11. Baker, C.J., R.W. Hoyt, T.E. Jones, C.S. Fulco, and A. Cymerman. Dietary considerations of a carbohydrate supplement at high altitude. FASEB J. 4(3):A567, 1990.

12. Edwards, J.S.A. and D.E. Roberts. Food and water intakes at environmental extremes. FASEB J. 4(3):A914, 1990.

PRESENTATIONS:

13. Askew, Eldon W., COL, Ph.D. Military nutrition research overview to COL John Cutting, Office of the Under Secretary of Defense for Acquisition/Research and Advanced Technology, Washington, DC. Natick, MA, March 1990.

14. Askew, Eldon W., COL, Ph.D. Update on relationship of carbohydrate levels in a combat ration to mental and physical performance to Dr. Hal Goforth, Naval Health Research Center, San Diego, CA. Natick, MA, April 1990.

15. Askew, Eldon W., COL, Ph.D. Institute overview briefing to Brigadier R.S. Mountford, OBE, UK Director of Clothing and Textiles. Natick, MA, May 1990.

16. Askew, Eldon W., COL, Ph.D. Military nutrition research briefing to Lt Col Yoram Epstein, IDF, Medical Corps, Israel. Natick, MA, May 1990.

MILITARY NUTRITION DIVISION

PRESENTATIONS:

17. Askew, Eldon W., COL, Ph.D. Military Nutrition Briefing to Colonel Meng Kin Lim, Chief Medical Officer, Singapore Armed Forces. Natick, MA, June 1990.

18. Baker, Carol J., R.D. Nutrition for work at altitude. Current Concepts in Environmental Medicine Course. Natick, MA, May 1990.

19. Baker-Fulco, Carol J., R.D. The functions and operation of the Military Nutrition Division CAN system to Dr. Catherine Johnson, LSU. Natick, MA, October 1990.

20. Edwards, J.S.A., Lt Col, Ph.D. Nutrition for work in the cold. Current Concepts in Environmental Medicine Course. Natick, MA, May 1990.

21. Edwards, J.S.A., Lt Col, Ph.D. Military Nutrition briefing to Dr. Tacker, Purdue University, PA. Natick, MA, May 1990.

22. Edwards, J.S.A., Lt Col, Ph.D. To Michael F. Haisman, Assistant Director, Head of Applied Physiology Division, Army Personnel Research Establishment, Great Britain. Natick, MA, September 1990.

23. Moore, Robert J., CPT, Ph.D. Nutrition for work in the heat. Current Concepts in Environmental Medicine Course. Natick, MA, May 1990.

KEY BRIEFINGS:

24. LTC Eldon W. Askew. USARIEM cold weather research program. International Cold Weather Research Symposium for Cooperative International Research, Minden, NV, February 1990.

25. LTC Eldon W. Askew. Military Nutrition Division support of the DOD food program. Colleen Cathcart, SA, DOD Food Program, Natick, MA, February 1990.

26. LTC Eldon W. Askew. Informed consent. Cadet volunteers for HURC #379, West Point, NY, March 1990.

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KEY BRIEFINGS:

27. LTC Eldon W. Askew. Role of sodium and micronutrients in sustaining soldier performance in hot environments. MG Philip K. Russell, Commander, MRDC, Natick, MA, April 1990.

28. LTC Eldon W. Askew. Ration sustainment. COL(P) Close, Commander, 1st Brigade, Fort Richardson, AK. Natick, MA, April 1990.

29. LTC Eldon W. Askew. USARIEM support of field ration testing. COL Peter Lichtenberger, Project Officer for Army Field Feeding System (AFFS), Belvoir RD&E Center. Natick RD&E Center, Natick, MA, August 1990.

30. COL Eldon W. Askew. Field ration testing. Members of 10th Mountain Division, 2nd Bde, Fort Drum, NY, October 1990.

31. COL Eldon W. Askew. Overview of Military Nutrition Division and research program. Brigadier J.B. Bloxham, Director, British Army Catering Corps. Natick, MA, October 1990.

32. COL Eldon W. Askew. Temperate climate test status. Joint Working Group, Army Field Feeding Systems, Fort Lee, VA, October 1990.

33. COL Eldon W. Askew. Military Nutrition overview. Lt Col Opher Berman, Technical Project Officer for the Data Exchange Agreement for Food, Israel. Natick, MA, November 1990.

34. COL Eldon W. Askew. Relationship of nutrition to physical fitness. COL Bruce Wicks, Commandant, Army Physical Fitness School, Fort Benjamin Harrison, IN. Natick, MA, November 1990.

35. COL Eldon W. Askew. Field ration testing. The U.S. Army Engineer School, SAPPER Leader Course, Fort Leonard Wood, MO, December 1990.

36. COL Eldon W. Askew. Military nutrition research. Colonel Colin W. Binns, Perth, Australia. Natick, MA, May 1990.

37. Carol J. Baker. Marine sports nutrition intervention. Mr. Christoper Forbes-Ewan, Tasmania, Australia. Natick, MA, April 1990.

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KEY BRIEFINGS:

38. Carol J. Baker. The nutritional and physiological aspects of military ration testing. The Experimental Foods Course of Framingham State College, Framingham, MA, April 1990.

39. Lt Col J.S.A. Edwards. Cold weather field ration testing. DIVARTY representatives, Fort Richardson, AK, January 1990.

40. Lt Col J.S.A. Edwards. Ration sustainment testing - Alaska and Bolivia. DOD Food and Nutrition Research and Engineering Board, Natick, MA, March 1990.

41. Lt Col J.S.A. Edwards. Cold weather nutrition briefing. Christopher Forbes-Ewan, Tasmania, Australia. Natick, MA, April 1990.

42. Lt Col J.S.A. Edwards. Alaska Cold Weather ration testing. COL(P) Close, Commander, 1st Brigade, Fort Richardson, AK. Natick, MA, April 1990.

43. Lt Col J.S.A. Edwards. Cold weather field ration testing and update on military nutrition research during Alaska and Bolivia field studies. Colonel J.G. Hamilton-Russel, Assistant Military Attache and Deputy Commander, British Army Staff, British Embassy, Washington, DC. Natick, MA, May 1990.

44. Lt Col J.S.A. Edwards. Results of Alaska field study 1990 and outline of Bolivia field study. Joint Working Group on Ration Sustainment Test Program, U.S. Army Belvoir RD&E Center, VA, June 1990.

45. Lt Col J.S.A. Edwards. Aspects of military nutrition field studies in Alaska and Bolivia. Brigadier E.F.G. Burton, OBE, British Army Staff. Natick, MA, September 1990.

46. Lt Col J.S.A. Edwards. High altitude test results to Joint Working Group, Army Field Feeding Systems, Fort Lee, VA, October 1990.

47. Christopher Forbes-Ewan, Materials Research Laboratory, Defence Science and Technology Organisation, Tasmania, Australia. Energy Expenditure Studies to Determine Food Requirements for Australian Soldiers seminar. Natick, MA, April 1990.

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KEY BRIEFINGS:

48. Tanya E. Jones. Test design for long life ration packet testing. Members of 10th Mountain Division, 2nd Bde, FT Drum, NY, October 1990.

49. Tanya E. Jones. Field ration testing. U.S. Army Engineer School, SAPPER Leader Course, Fort Leonard Wood, MO, December 1990.

50. CPT Robert J. Moore. Carbohydrate loadbearing and sodium studies. Brigadier J.B. Bloxham, Director, British Army Catering Corps. Natick, MA, October 1990.

51. Lt Col J.S.A. Edwards. Alaska field study 1990 and Bolivia field study 1990. Brigadier J.B. Bloxham, Director, British Army Catering Corps. Natick, MA, October 1990.

SIGNIFICANT TDY:

LTC Eldon W. Askew. To participate in General Officer Soldier Systems Review focusing on rations and individual soldier equipment. Natick RD&E Center, Natick, MA, 3 January 1990.

LTC Eldon W. Askew. To brief ration testing plan to Ration Sustainment Testing Meeting. Fort Belovir, VA, 10 January 1990.

LTC Eldon W. Askew. To attend an International Cold Weather Research Symposium for Cooperative International Research. Minden, NV, 12-15 February 1990.

LTC Eldon W. Askew. To conduct a joint service planning workshop to develop a sports nutrition intervention project.
Arlington, VA, 6 March 1990.

LTC Eldon W. Askew. To present paper at Federation of American Societies of Experimental Biology. Washington, DC,
1-6 April 1990.

LTC Eldon W. Askew and Lt Col J.S.A. Edwards. To participate in a Joint Working Group to review ration sustainment testing and results. Fort Belvoir, VA, 14 June 1990.

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SIGNIFICANT TDY:

LTC Eldon W. Askew, Lt Col J.S.A. Edwards, Elaine Christensen, Carlo Radovsky, and Ann Curran. To participate in field study HURC #398, "Fuertes Camino (90): predictability of altitude illness, acute physiological changes, and assessment of nutritional intakes of U.S. Army soldiers operating at high altitude." Potosi, Bolivia, 16 July-13 August 1990.

COL Eldon W. Askew, Lt Col J.S.A. Edwards, and MAJ Nancy King. To attend Joint Working Group, Army Field Feeding Systems. U.S. Army Belvoir RD&E Center, VA, 22-23 October 1990.

COL Eldon W. Askew and Doris E. Sherman. To attend DOD Food and Nutrition Research and Engineering Board (FNREB). U.S. Army Natick RD&E Center, MA, 1 November 1990.

COL Eldon W. Askew and CPT Cecilia D. Thomas. To attend Committee on Military Nutrition Research Meeting - revision of MRDAs. Washington, DC, 26-27 November 1990.

COL Eldon W. Askew. Liaison to Fort Polk, LA and Pennington Biomedical Research Institute. Baton Rouge, LA, 12-14 December 1990.

Carol J. Baker. To participate in joint military planning meeting and workshop on the U.S. Army/U.S. Marine Corps performance nutrition intervention project. Arlington, VA, 6 March 1990.

Carol J. Baker. To participate in the Army Nutrition Planning Committee meeting, Fort Benjamin Harrison, IN, 20-21 March 1990.

Carol J. Baker-Fulco and a study team of 13 data collectors and support personnel. To conduct USA/USMC field study HURC #415, "Baseline dietary assessment of U.S. Marine Corps officer candidate school students for the performance nutrition intervention project." U.S. Marine Corps Combat Development Command, Quantico, VA, 12-25 August 1990.

Lt Col J.S.A. Edwards, Ph.D., Carol J. Baker, Tanya E. Jones, and a support team of 10 personnel. To conduct field study HURC #392, "A comparison of the Meal, Ready-to-Eat (MRE) with supplement pack and the ration, cold weather (RCW) consumed in an arctic environment." Fort Wainwright/Fort Greely, AK, 3-16 February 1990.

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SIGNIFICANT TDY:

Lt Col J.S.A. Edwards. Site visit for control measurements in preparation for Bolivia field study. Fort Riley, KS, 17-18 April 1990.

Tanya E. Jones. Army Field Feeding System (AFFS) Menu Work Group meeting, Fort Lee, VA, 5-6 March 1990.

Tanya E. Jones and COL Eldon W. Askew. Site visit preliminary to field study HURC #417, "A field evaluation of the nutritional intake and acceptability of the long life ration packet (LLRP) consumed in a temperate environment," and HURC #418, "A field evaluation of the nutritional intake and acceptability of the new generation survival ration (NGSR) consumed in a temperate environment." Fort Drum, NY, 2-3 October 1990.

Tanya E. Jones and COL Eldon W. Askew. Site visit HURC #417 and HURC #418. Fort Leonard Wood, MO, 9-11 December 1990.

CPT Robert J. Moore. To recruit, medically screen, and select U.S. Marine Corps test subject volunteers for a research study. Camp Lejeune, NC, 16-18 May 1990.

Doris E. Sherman. Site visit preliminary to HURC #379, "Nutrition assessment of U.S. Military Academy cadets at West Point," January 1990.

Doris E. Sherman. Site visit preliminary to HURC #379, February 1990.

Doris E. Sherman and a team of 30 people including physiologists, dietitians, and data enterers. Field study HURC #379. West Point, NY, 25-31 March 1990.

Doris E. Sherman. To attend the Fifteenth National Nutrient Databank Conference. Blacksburg, VA, 3-6 June 1990.

Doris E. Sherman. To observe testing of modified recipes at Louisiana State University. New Orleans, LA, 24-27 September 1990.

Doris E. Sherman. To participate in Research and Development Associates meeting focusing on irradiation of food. Boston, MA, 30-31 October 1990.

MILITARY NUTRITION DIVISION

SIGNIFICANT TDY:

CPT Cecilia D. Thomas. To present poster at American Dietetic Association Meeting. Denver, CO, 16-17 October 1990.

CPT Cecilia D. Thomas. To attend meeting of Committee on Military Nutrition. Washington, DC, 27 November 1990.

CPT Cecilia D. Thomas. To attend Army Nutrition Planning Committee. Washington, DC, 28-29 November 1990.

SIGNIFICANT VISITORS:

Theresa Nicklas, Ph.D., Dietitian, School of Medicine, Louisiana State University. Liaison visit regarding Louisiana State University grant, 7-8 March 1990.

Christopher Forbes-Ewan, Materials Research Laboratory, Defence Science and Technology Organisation, Tasmania, Australia, 8-12 April 1990.

Colonel Colin W. Binns, Nutritional Advisor to the Armed Forces of Australia, 17 May 1990.

Colonel J.G. Hamilton-Russel, Assistant Military Attache and Deputy Commander, British Army Staff, British Embassy, Washington, DC., May 1990.

Brigadier R.S. Mountford, OBE, United Kingdom Director of Clothing and Textiles, May 1990.

Brigadier E.F.G. Burton, OBE, Military Attache and Commander, British Army Staff, British Embassy, Washington, DC, 12-13 September 1990.

Sigmund Folkvord, Technical Director, Compact AS Company, Berger, Norway, who detailed the seven oceans ration that has a nutrient composition similar to the NGSR (field testing of both a possibility), 17-18 September 1990.

Brigadier J.B. Bloxham, Director, British Army Catering Corps. Natick, MA, October 1990.

MILITARY NUTRITION DIVISION

SIGNIFICANT VISITORS:

Catherine Johnson, Ph.D., Dietitian, Pennington Biomedical Research Center, Baton Rouge, LA. Coordination and liaison visit also involving aspects of U.S. Army Natick RD&E Center specifically on menu modification, 10-12 October 1990.

Donna H. Ryan, M.D., Associate Executive Director, Pennington Biomedical Research Center, Baton Rouge, LA. Liaison visit on Louisiana State University grant, 30 November 1990.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

COL Eldon W. Askew, Ph.D. Member, High Heat Environment Food Quality Task Force, Natick Research, Development and Engineering Center, Natick, MA.

COL Eldon W. Askew, Ph.D. Member, Panel of Judges, Third Natick Science Symposium, 5-6 June 1990.

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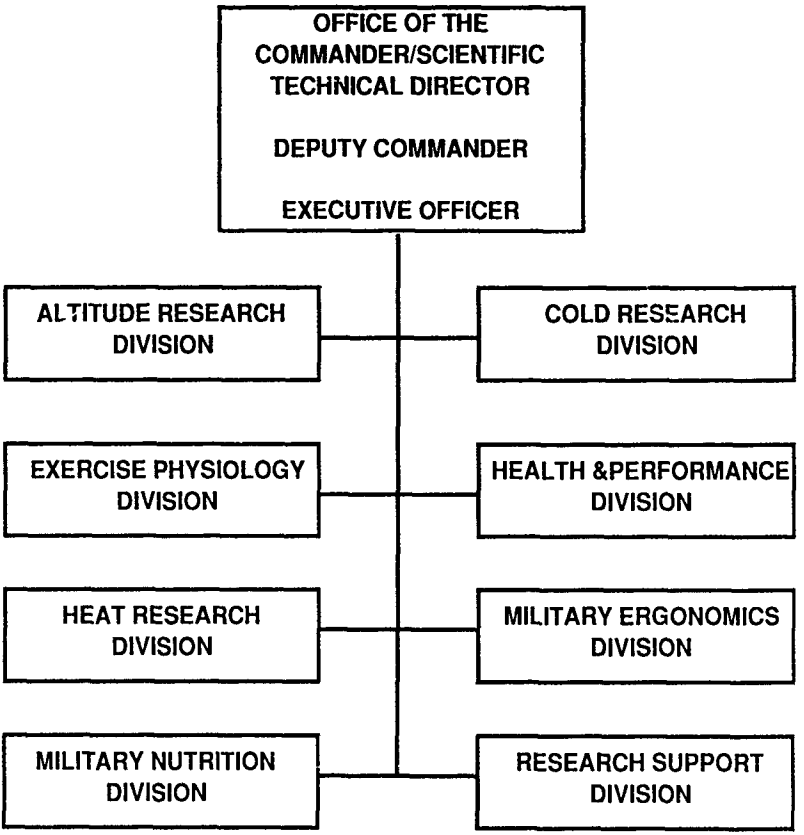

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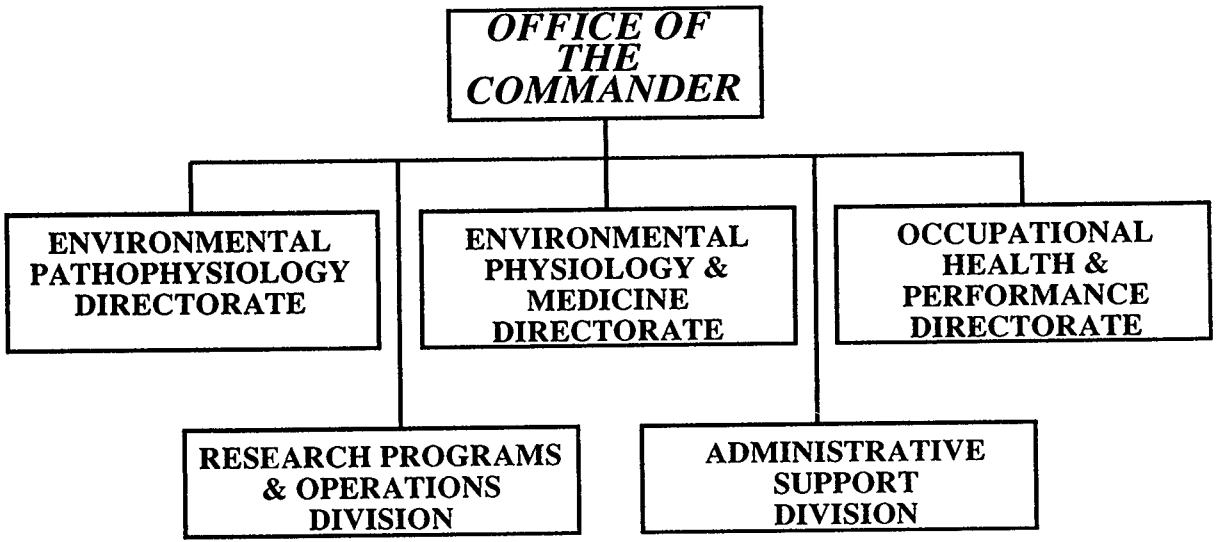

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